# Investigating the Relationship between Sleep Quality and Intrusive Memories in Post-Traumatic Stress Disorder

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I declare that this report is my own original work and that contributions of others have been duly acknowledged.

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## Contents

## List of Tables and Figures

Investigating the Relationship between Sleep Quality and Intrusive Memories in PTSD

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## Abstract

The Sleep to Forget, Sleep to Remember model (Walker, 2009) suggests that sleep quality influences emotional memory consolidation. This model has relevance to intrusive memories in PTSD, since theories of PTSD posit that intrusive memories are a product of inadequate processing of emotional memories (Brewin, Dalgleish, & Joseph, 1996; Ehlers & Clark, 2000). The present study aims to investigate the moderating effect of sleep on the relationship between PTSD and intrusive memories. 34 PTSD, 44 trauma exposed (TE) and 40 non-trauma exposed (NTE) participants completed an emotional memory task, where they viewed 60 images (20 positive, 20 negative and 20 neutral) and, two days later, reported how many intrusive memories they had of each valence category. Participants also completed three measures of sleep quality: the Pittsburgh Sleep Quality Index, the REM Behaviour Disorder Screening Questionnaire and total hours slept before the second session. The PTSD group reported poorer sleep quality than control groups on all three measures, and significantly more negative intrusive memories than the NTE group. Moderation analyses revealed that hours of sleep before the second session moderated the relationship between PTSD symptomology and intrusive memories, as predicted by Sleep to Forget, Sleep to Remember (Walker, 2009).

Posttraumatic stress disorder (PTSD) is a mental health condition that may develop following a criterion A trauma, defined as exposure to an incident involving actual or threatened death, serious injury, or sexual violence (Diagnostic and Statistical Manual of Mental Disorders, 5th ed. [DSM-5], American Psychiatric Association [APA], 2013). PTSD is a disabling condition affecting 6.4% of the Australian population (Australian Bureau of Statistics, 2007). The core symptoms of PTSD include re-experiencing trauma (ie. intrusive memories and nightmares), physiological hyperarousal, negative cognitions and mood, as well as avoidance of trauma reminders (APA, 2013). Sleep disturbances, including insomnia and nightmares, also characterize PTSD (APA, 2013; Kobayashi, Boarts, & Delahanty, 2007).

Converging evidence suggests that sleep disturbances may underlie PTSD symptoms - in particular intrusive memories (Germain, 2013; Goldstein & Walker, 2014). The relationship between PTSD and intrusive memories may be explained by the Sleep to Forget, Sleep to Remember model, which suggests that sleep enhances semantic memory for emotional experiences, whilst simultaneously reducing the emotional charge of these memories (Walker, 2009). Sleep disturbances in PTSD may reflect malfunctioning physiological conditions disrupting these memory processes (Goldstein & Walker, 2014), which results in intrusive memories (Brewin, Gregory, Lipton, & Burgess, 2010; Goldstein & Walker, 2014). The only two studies that have empirically examined the relationship between trauma, sleep and intrusive memories have found conflicting results (Kleim, Wysokowsky, Schmid, Seifritz, & Rasch, in press; Porcheret, Holmes, Goodwin, Foster, & Wulff, 2015). This thesis therefore aims to investigate the relationship between sleep and intrusive memories in PTSD.

**Emotional Memory Consolidation and Sleep**

Memories that are retained long-term proceed through several stages of processing. During encoding, an observed event or interaction is symbolically represented for a short time in the brain (Walker & Stickgold, 2006). Representations that are selected for retention as long-term memories are stabilized and enhanced during the 'consolidation' phase (McGaugh, 2000). Converging evidence suggests that emotional memories are selectively consolidated and subsequently better remembered than neutral memories (Cahill & McGaugh, 1998; McGaugh, 2004; Phelps, 2004). This may be because emotional events are more likely to be meaningful and pertinent to survival, such that lasting memories of these events will be advantageous in the future. Release of noradrenaline and cortisol during emotional experiences activates the amygdala through the autonomic nervous system, which in turn influences the strength and longevity of memories consolidated by the hippocampus (McGaugh, 2004; Phelps, 2004). The hippocampus then consolidates these memories into long-term memory in context with other memories and information (Chun & Phelps, 1999; Daumas, Halley, Frances, & Lassalle, 2005). In this way, adaptive selection of emotional over neutral experiences for long-term memory retention is achieved biologically (McGaugh, 2004; Phelps, 2004).

Sleep appears to be important in the selective consolidation of emotional memories (Genzel, Spoormaker, Konrad, & Dresler, 2015; Payne & Kensinger, 2010; Walker & Stickgold, 2006). Sleep in humans can be separated into two distinct, nightly phases: rapid-eye-movement (REM) sleep and non-REM sleep (Hobson, Pace-Schott, & Stickgold, 2000). During REM sleep, there is increased activity in limbic and anterior paralimbic areas of the brain, including the amygdala and hippocampus, which are associated with emotions and memory processes (Nir & Tononi, 2010; Nofzinger, 2005). There are decreased noradrenergic levels in these areas of the brain during REM sleep, and acetylcholine levels

increase (McGaugh, 2004; Vazquez & Baghdoyan, 2001). This rebalancing of neurotransmitters promotes emotional memory consolidation (McGaugh, 2004). REM sleep is also marked by theta-range frequencies in limbic areas of the brain, which seem to facilitate inter-region communication between areas associated with emotional processing (Hutchison & Rathore, 2015). Accordingly, changes in neurophysiological and neurochemistry conditions in the brain during REM sleep seem ideal for emotional memory consolidation (Goldstein & Walker, 2014).

In a behavioral study, Wagner and colleagues (2006) found that participants who briefly slept after reading neutral and emotional texts experienced enhanced memories of emotional but not neutral texts for several years. Conversely, a control group that did not sleep after reading had no lasting memory of either text (Wagner, et al., 2006). Similarly, Payne and colleagues (2008) found that participants in a sleep condition recalled emotional components of scenes above neutral components, compared to a wake condition that experienced forgetting of both emotional and neutral components. Evidence of selective emotional consolidation following sleep has been replicated elsewhere (Payne, Chambers, & Kensinger, 2012; Payne, Kensinger, Warnsley, Spreng, & Alger, 2015; Wagner, Gais, & Born, 2001), with some research finding positive correlations between REM duration and emotional memory (Nishida, Pearsall, Buckner, & Walker, 2009).

**Sleep to Forget, Sleep to Remember (SFSR: Walker, 2009)**

Walker (2009) integrated these findings to propose the Sleep to Forget, Sleep to Remember (SFSR) model of emotional memory consolidation. According to SFSR, REM sleep simultaneously enhances semantic memory for emotional experiences, whilst attenuating the associated emotional charge (see Figure 1, Goldstein & Walker, 2014; Walker, 2009). In this way, the emotional arousal that initially indicated which experiences were important for long-term retention is reduced by subsequent sleeps, such that memory for

the emotional experience is retained, but the affective charge is not (Walker, 2009). Damage to this system is hypothesized to result in ongoing distress to emotional experiences, and to reflect distressing symptoms of psychiatric disorders (Walker & van der Helm, 2009).

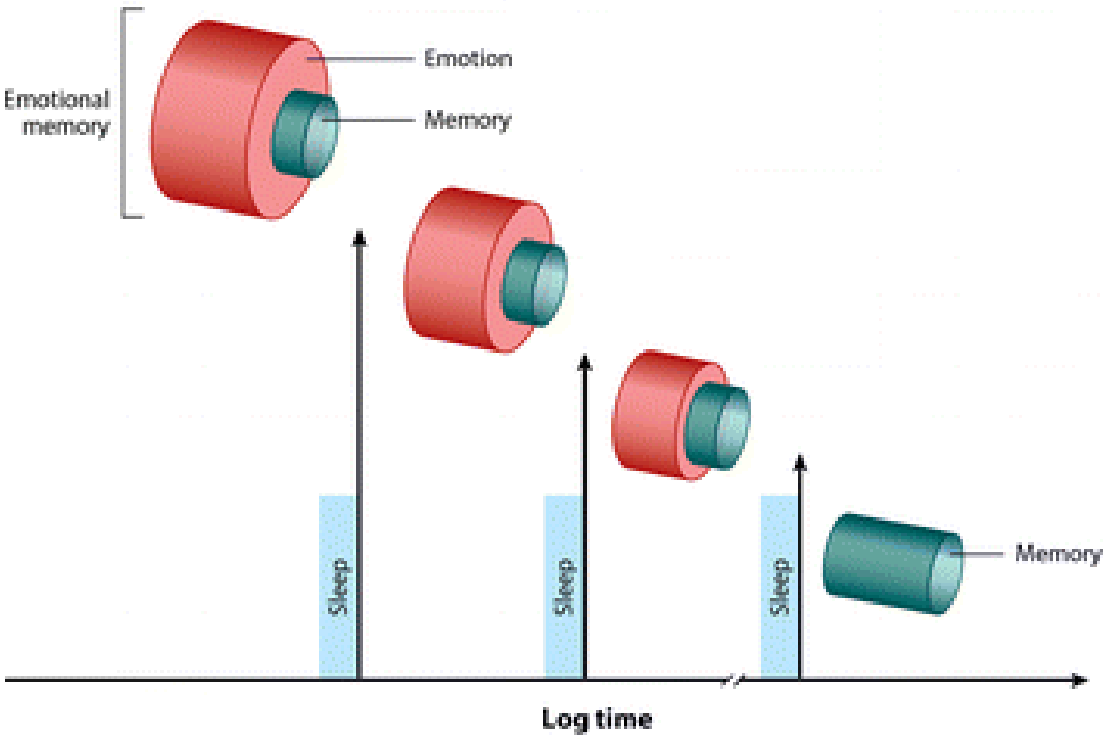


*Figure 1.* In Sleep to Forget, Sleep to Remember (Walker, 2009), sleep reduces the affective tone of emotional memories, whilst maintaining the semantic memory for the event.

SFSR also suggests that dreaming may consciously express sleep-based emotional memory consolidation (Walker & van der Helm, 2009), an idea substantiated by other authors (reviewed in Mallnowski & Horton, 2015). Dreaming seems to be largely dependent on REM processes (Hobson, et al., 2000), and dreams tend to relate to daily concerns (Schredl, 2003), with more intense emotional daytime events more likely to be the subject of dreams (Schredl, 2006). Further, dreams during REM sleep are usually emotional in content

(Hobson, et al., 2000). It is therefore thought that dreaming may be a feature of emotional memory processes (Goldstein & Walker, 2014; Mallnowski & Horton, 2015).

**Evidence for SFSR**

The Sleep to Remember component of SFSR has been largely supported. For instance, Wiesner and colleagues (2015) assessed the efficacy of slow wave sleep (SWS) and REM sleep in consolidating emotional memories (see Figure 2). In this experiment, participants performed a delayed recognition task of emotional and neutral images after being deprived of SWS or REM sleep in a sleep laboratory. They found that REM-deprived participants had comparatively impaired memory for emotional images (Wiesner, et al., 2015). This finding has been replicated (Groch, Zinke, Wilhelm, & Born, 2015; Groch, Wilhelm, Diekelmann, & Born, 2013), and multiple other studies have found a general effect of sleep on emotional memories of images, text and films (Hu, Stylos-Allan, & Walker, 2006; Menz, et al., 2013; Nishida, et al., 2009; Payne, et al., 2008; Payne et al., 2012; Payne et al., 2015; Wagner, et al., 2001; Wagner, et al. 2006). However, some studies have supported the role of SWS over REM in emotional memory consolidation (Ackermann & Rasch, 2014; Payne, et al., 2015).

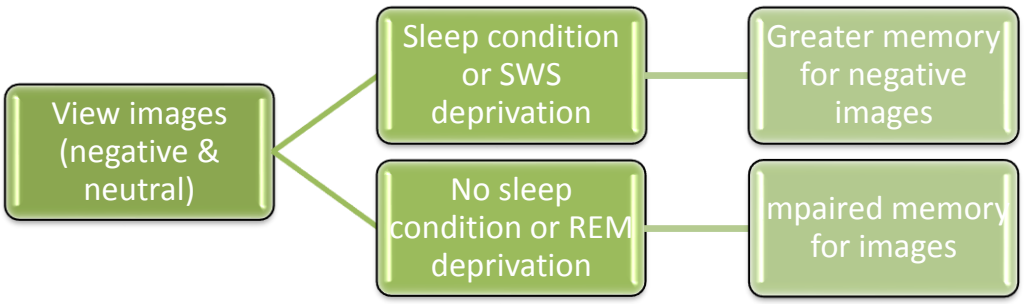


*Figure 2.* Basic paradigm and results for the effect of sleep versus no sleep on emotional memory consolidation (eg., Wiesner, et al., 2015)

Whether sleep simultaneously de-potentiates the emotional charge of these memories is more controversial. This aspect of SFSR has been investigated by manipulating sleep quality, whilst rating the aversiveness of emotional stimuli (images or films) before and after the manipulation (see Figure 3). Although some studies have supported an aversion-reducing effect of sleep following exposure to negative stimuli (Cunningham, et al., 2014; van der Helm, Yao, Dutt, Rao, Saletin, & Walker, 2011), others have been unable to replicate this (Groch, et al., 2013; Wiesner, et al., 2015), or have found the opposite effect (Baran, Pace-Schott, Ericson, & Spencer, 2012; Kuriyama, Soshi, & Kim, 2010; Menz, et al., 2013; Porcheret, et al., 2015; Werner, Schabus, Blechert, Kolodyazhniy, & Wilhelm, 2015; Wagner, Fisher, & Born, 2002).

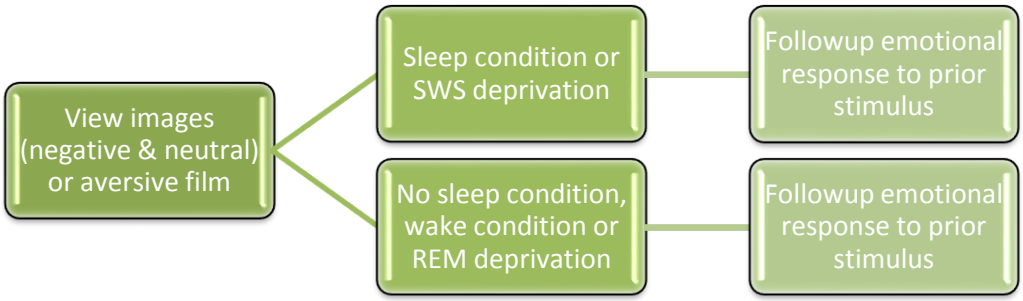


*Figure 3*. Typical paradigm testing the effect of sleep (REM, SWS or unspecified) on emotional reactivity

Differences in results may be due to the latter studies using more sleep deprivation and more aversive paradigms (ie. film paradigms) than studies finding a cathartic effect of sleep. Regardless, these studies all focused on single-night sleep manipulations, whereas SFSR predicts consolidating effects over many sleeps (Walker, 2009; see Figure 1). Further, studies of the Sleep to Forget component of SFSR have examined reactivity to the same stimuli following sleep manipulation, whereas SFSR relates to ongoing distress in absence of

stimuli (Walker, 2009). Increased reactivity when confronted by the same aversive stimuli after sleep could reflect adaptivity rather than fragility, since the feared object will be advantageously feared and avoided (Goldstein & Walker, 2014). More research is needed to discern the effect of sleep on emotional wellbeing.

**Emotional Memories in PTSD**

PTSD is characterized by emotional memory dysfunction (Brewin, et al., 2010; Brewin, 2011). PTSD patients experience both a reduction in explicit memory recall (Brewin, Kleiner, Vasterling, & Field, 2007) and spontaneous, distressing memories of traumas, known as intrusive memories (APA, 2013). Intrusive memories are fragmented trauma memories that are not deliberately or willingly accessed (Ehlers, 2010). Conversely, PTSD patients lack specificity in their explicit recollection of traumas, such that they often struggle to recall important aspects of the event (Brewin, 2011; Ehlers, 2010). Lack of specificity of explicit memories following trauma seems to predict PTSD onset (Kleim & Ehlers, 2008), and memory deficits extend to non-emotional content, such as verbal memory (Brewin, et al., 2007). Neuroimaging evidence shows that PTSD patients have hippocampal volume reductions (Acheson, Gresack, & Risbrough, 2012; Childress, et al., 2013; Liberzon & Sripada, 2008), which may underlie inadequate consolidation and contextualization of explicit traumatic memories and negative events (Acheson, et al., 2012; Brewin, et al., 2010). This aligns with the neuroscientific model of memory consolidation, which suggests the hippocampus is heavily involved in consolidating and providing contextual information for memories (Chun & Phelps, 1999; Phelps, 2004).

**Sleep Disturbances in PTSD**

Sleep disturbances, including insomnia, night-time awakenings and recurring nightmares, are also a core symptom of PTSD (APA, 2013). Subjective reports indicate that 70%-91% of PTSD patients suffer from sleep disturbances (Maher, Rego, & Asnis, 2006).

Objective ratings of sleep disturbances in PTSD confirm self-reports (Germain, 2013; Kobayashi, Huntley, Lavela, & Mellman, 2012). Polysomnography refers to the gold standard measurement of sleep, comprised of EEG, EMG and ECG recordings (Germain, 2013). In a recent meta-analysis of polysomnographically measured sleep in PTSD, PTSD patients exhibited less non-REM and had overall lighter sleep than controls (Kobayashi, et al., 2007). Additionally, people with PTSD display increased REM density, which refers to the number of rapid-eye movements per REM cycle, even though the cycles tended to be shorter in duration compared to healthy controls (Kobayashi, et al., 2007). REM sleep seems to fundamentally change after trauma, and these changes maintain throughout PTSD (Mellman, Kobayashi, Lavela, Wilson, & Hall Brown, 2014). Recent research has also shown shared neuroanatomic etiology between insomnia and PTSD, such as the amygdala and hippocampus, emphasizing the importance of sleep disturbance in PTSD (Nardo, Hogberg, Jonsson, Jacobsson, Hallstrom, & Pagani, 2015).

PTSD patients also suffer repetitive, trauma-related nightmares (APA, 2013). Although there is less evidence for the role nightmares play in the disorder (Germain, 2013), theoretical perspectives suggest that dreams consciously reflect sleep-dependent memory consolidation processes (Mallnowski & Horton, 2015). Accordingly, some authors suggest that nightmares relate to problematic memory consolidation during REM sleep (Levin & Nielsen, 2009). Since nightmares in PTSD tend to be recurring re-experiencing of traumatic events (APA, 2013), it seems possible that they reflect malfunctioning consolidation processes characteristic of the disorder (Germain, 2013).

**Sleep, SFSR and PTSD: A Converging Hypothesis**

Since sleep is highly involved in emotional memory consolidation, multiple authors have suggested that sleep disturbances form part of PTSD etiology, rather than being a secondary symptom of the disorder (Germain, 2013; Goldstein & Walker, 2014; Spoormaker

& Montgomery, 2008; Stickgold, 2002). Germain and colleagues (2008) postulated that PTSD-related disturbances during REM sleep result from amygdala hyperactivity and reduced activity in the ventromedial prefrontal cortex (vmPFC), an area known to inhibit emotional responses (Delgado, Nearing, LeDoux, & Phelps, 2008). According to this model, emotional signals produced by the amygdala and failed suppression of these signals by the vmPFC contribute to a state of hyperarousal, which interrupts normal sleep (Germain, et al., 2008). This approach aligns with the prevailing neurobiological model of PTSD, which suggests that disrupted inhibition from the vmPFC and hippocampus to amygdala-related fear networks results in ongoing fear responses that reflect PTSD symptoms (Pitman, et al., 2012). It also aligns with SFSR, which suggests that neurobiological conditions during healthy REM sleep are conducive for emotional memory consolidation (Walker, 2009). Accordingly, theta-range frequencies during REM sleep have been shown to be disturbed in PTSD samples, implying a reduction in inter-region communication between the amygdala, vmPFC and hippocampus during REM sleep (Cohen, et al., 2013; Cowdin, Kobayashi, & Mellman, 2014; Nishida, et al., 2009). Further, noradrenergic activity does not abate during sleep in PTSD samples (Mellman, Kumar, Kulick-Bell, Kumar, & Nolan, 1995), and the area responsible for noradrenergic regulation – the locus coerulus – appears to be dysfunctional during sleep in PTSD (Germain, et al., 2013).

Distress in PTSD may therefore result from the failed decoupling of emotions from traumatic memories during disturbed sleep, which may perpetuate as the nervous system repeatedly attempts – but fails – to de-potentiate and consolidate the memory (van der Helm & Walker, 2012). In support, it has been noted that sleep disturbances following traumatic events predict future PTSD onset (Babson & Felder, 2010; Mellman & Hipolito, 2006), and sleep restoration seems to improve waking PTSD symptoms (Barr, Livingston, Guarado, Baxter, Mysliwiec, & Gill, 2015; Ho, Chan, & Tang, 2016). Further, recurrence of traumatic

event-related nightmares in PTSD may reflect disruption of this SFSR process, if dreaming indeed reflects emotional memory consolidation (Germain, 2013).

**Intrusive Memories in PTSD**

Convergences in the sleep, emotional memory and PTSD literature are highly relevant to intrusive memories in PTSD. Intrusive memories – a defining feature of PTSD (APA, 2013) – relate to impaired emotional memory consolidation following traumatic exposure (see Figure 4, Brewin, et al., 2010; Conway & Pleydell-Pearce, 2000; Ehlers & Clark, 2000). Intrusive memories in PTSD are distressing, involuntary and brief memories that invoke a sense of "here and now" when experienced (Michael, Ehlers, Halligan, & Clark, 2005). Intrusive memories in PTSD are also detached from normal, explicit memory, which makes them hard for patients to voluntarily recall or chronologically sequence (Brewin, Dalgleish, & Joseph, 1996; Kleim, Wallott, & Ehlers, 2008).

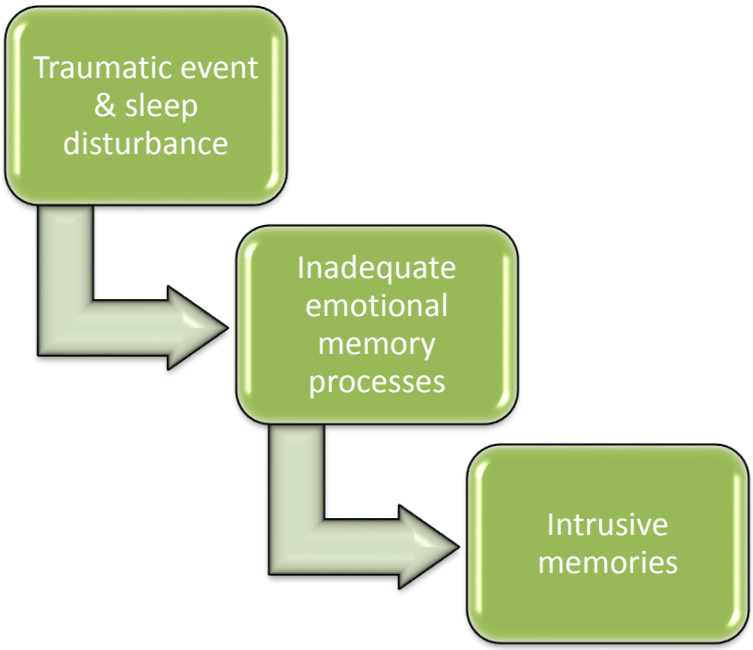


*Figure 4.* Inadequate emotional memory consolidation resulting from sleep disturbance following trauma may directly produce intrusive memories

In contrast, autobiographical memories are congruent with our psychological homeostasis, and are the explicit memories that we recognize as definitive of ourselves (Conway & Pleydell-Pearce, 2000). The Dual Representation model of PTSD (Brewin, et al., 1996; Brewin, et al., 2010) posits that intrusive memories reflect inadequate contextualization of sensory and affective components of traumatic memories into autobiographical memory. In this model, lower-order memories have affective, sensory and tactile components relating to the event, whereas higher-order memories are contextualized groupings of these experiences congruent with autobiographical networks (Brewin, et al., 1996). According to Brewin and colleagues (2010), over-activation of the noradrenergic system and amygdala during trauma disrupts laying down autobiographical memories by impairing the function of the hippocampus, which provides contextual information for lower-order memory components. Lack of contextualization enables memories to be readily primed in their sensory, affective states across non-salient situations (Brewin, et al., 2010). This approach is supported by neuroanatomical observations of reduced hippocampal volume (Acheson, et al., 2012; Childress, et al., 2013; Liberzon & Sripada, 2008; O'Doherty, Chitty, Saddiqui, Bennett, & Lagopoulos, 2015) and amygdala hyperactivity (Liberzon & Sripada, 2008; O'Doherty, et al., 2015) in PTSD.

**SFSR and Intrusive Memories**

Similarly, SFSR suggests that emotional events lose their affective tone as they are processed into autobiographical networks that can comprehend and cognitively assimilate the experience (Walker & van der Helm, 2009). Emotional memories are further consolidated and de-potentiated each time they are retriggered, and so may continuously retrigger if they fail to integrate into autobiographical memory (Walker & van der Helm, 2009). This is congruent with leading theories of PTSD, which purport that exposure therapies promote consolidation of the affective components of events into autobiographical context by

continuous re-exposure (Brewin, et al., 2010; Ehlers & Clark, 2000). Although similar, SFSR is unique in that it proposes this process naturally occurs due to physiological conditions during REM sleep (Goldstein & Walker, 2014; and see Stickgold, 2002).

If emotional memory consolidation deficiencies are produced by sleep disturbance (Walker, 2009), and intrusive memories reflect failure of emotional memory consolidation and contextualization in PTSD (Brewin, et al., 2010; Ehlers & Clark, 2000), it follows that sleep disturbances in PTSD should underlie intrusive memories. Although preliminary, there is some support for this argument. Firstly, there are neural similarities between sleep-dependent emotional memory consolidation and mechanisms in Brewin's Dual Representation model (Brewin, et al., 2010). For instance, Brewin and colleagues (2010) postulated that, in PTSD, the hippocampus fails to provide adequate contextualization for traumatic experiences - a process that can occur during sleep (Marshall & Born, 2007). Congruently, neuroimaging studies have shown that the hippocampus, as well as the amygdala and vmPFC, are abnormally activated during REM sleep in PTSD (Ebdlahad, Nofzinger, James, Buyesse, Price, & Germain, 2013; Germain, et al., 2013; Liberzon & Sripada, 2008), suggesting that structures involved in consolidation and contextualization of trauma memories are dysfunctional in PTSD (Germain, et al., 2008; Nardo, et al., 2015). Moreover, sleep improves exposure therapy outcomes across many clinical disorders, suggesting that exposure therapy and sleep share memory consolidation and extinction mechanisms (Kleim, Wilhelm, Temp, Wiederhold, & Rasch, 2014).

Some research has also found a positive relationship between sleep and contextual memory consolidation, believed to be a function of the hippocampus (Frankland & Bontempi, 2005). In one study, participants who slept after implicit contextual tasks had greater memory for contextual elements in subsequent testing (Spencer, Summ, & Ivry, 2006). Moreover, Lewis, Cairney, Manning and Critchley (2011) showed that memories for

contextual information were better recalled after 12 hours sleep than 12 hours wake, and that this improvement was associated with hippocampal activity. Similarly, in a study measuring sleep spindles and memory for contextual information, participants who napped exhibited greater memory for contextual information than those who did not nap (Cairney, Durrant, Jackson, & Lewis, 2014). This research links sleep with contextual memory consolidation, which is thought to be a key factor in intrusive memory development (Brewin, et al., 2010; Ehlers & Clark, 2000).

**Gaps in the Literature**

To date, there have only been two empirical studies examining the relationship between trauma, sleep and intrusive memories. Kleim and colleagues (in press) found that a sleep group experienced less intrusive memories of a traumatic film than wake or sleep deprivation groups. In this study, participants viewed an aversive film before polysomnographically recorded sleep, sleep deprivation or daytime-wake. Over the following week, they completed an intrusive memory diary. Results indicated a protective effect of early sleep onset on intrusive memory development, whereas higher REM density (an irregular pattern of REM sleep typically observed in PTSD, see Kobayashi, et al., 2007) predicted more intrusive memories. These results support the idea that good sleep minimizes intrusive memory development (Kleim, et al., in press). Conversely, Porcheret and colleagues (2015) measured the intrusive memories of a sleep deprived group and a sleep as usual group six days after watching a trauma film. In contrast to Kleim and colleagues (in press), they found the sleep group experienced more intrusive memories than the sleep deprived group, suggesting a protective effect of sleep deprivation on intrusive memory development (Porcheret, et al., 2015). As noted in Kleim, et al. (in press), however, this effect was only significant the first day after the trauma film, and seemed to begin reversing five days later. Unfortunately, the conflict between these studies is unresolved, and neither

study included PTSD participants. More research is therefore needed to discern the sleep-intrusion relationship.

## Aims and Hypotheses

The present study aims to empirically investigate the relationship between sleep disturbance, intrusive memory development and PTSD, and to test the predictions of the SFSR model (Walker, 2009). We will use a similar paradigm to previous human behavioral research examining sleep and emotional memory, by presenting a series of emotional images of varying valence to PTSD and non-PTSD participants. Participants will provide ratings of their sleep quality and a diary of their intrusive memories of these images between testing sessions.

We hypothesise that:

1. Participants with PTSD will have poorer sleep quality compared to trauma exposed (TE) and non-trauma exposed (NTE) participants, as measured by the Pittsburgh Sleep Quality Index (PSQI: Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), an acute sleep diary indexing hours of sleep and the REM Behaviour Disorder Screening Questionnaire (RBDSQ: Stiasny-Kolster, Mayer, Schafer, Moller, Heinzel-Gutenbrunner, & Oertel, 2007).
2. PTSD participants will experience more negative intrusive memories of emotional images than TE or NTE groups.
3. The relationship between PTSD symptomology and number of intrusive memories will be moderated by sleep quality, such that participants with good sleep quality and high PTSD symptomology will be protected from intrusive memories, and participants with poor sleep quality will be more likely to develop intrusions if they have higher PTSD symptomology.

## Method

### Participants

Participants were recruited from University of Tasmania, as well as from the university psychology clinic and other private psychology clinics in Hobart. First-year psychology students received course credit for their participation. Students and members of the public outside this cohort received $30 reimbursement. A-priori power analysis using G-Power v3.1.9.2 indicated that detection of a medium effect ($f^2 = .11$) with 0.8 power required 113 participants. In total, 136 participants[1] completed the study (female = 81, age M = 27.24, SD = 11.16). 44 were non-trauma exposed controls (NTE), as determined by the Traumatic Experiences Questionnaire (TEQ: Vrana & Lauterbatch, 1994, female = 28). 57 participants were classified as trauma exposed controls (TE) as they met criteria for exposure to a criterion A trauma (female = 33), as measured by the TEQ, but did not meet the diagnostic criteria for PTSD or display symptoms at subsyndromal levels as determined by the PTSD CheckList – Civilian Version (PCL-C: Foa, Cashman, Jaycox, & Perry, 1997). 35 participants were categorized as having PTSD (female = 20), as they met DSM-IV criteria for PTSD as measured by the PCL-C, or displayed symptoms at a level considered subsyndromal PTSD (PCL total >40, National Center for PTSD).

In the TE group, 13 participants reported physical or sexual assault, 17 reported having been in an accident, 2 reported a natural disaster, 22 reported a close friend or relative suffer an assault or serious accident, 1 reported combat experience and 2 did not disclose their traumas but reported experiencing significant trauma. In the PTSD group, 17 participants reported physical or sexual assault, 8 reported accidents, 1 reported a natural

[1]29 of these participants were collected in 2016 as part of this honours project – the rest were collected during previous years.

disaster, 4 reported combat experience, 2 reported a secondary accident and 3 chose not to disclose their trauma.

Exclusion criteria included current psychiatric diagnosis or medication in controls, aged outside 18-60, traumatic brain injuries, history of head injury resulting in loss of consciousness for over five minutes or hospitalization, an AUDIT (The Alcohol Use Disorders Identification Test: WHO, 2001) score of over 19 or a disclosed substance dependence. These exclusions controlled for memory loss.

**Design**

Our first hypothesis utilized a between groups design, comparing subjective sleep quality between groups (Group [PTSD, TE, NTE]), with PSQI, acute sleep duration and REM disturbance scores as outcome variables. A 3 x 3 (Valence of images [positive, neutral, negative] x Group [PTSD, TE, NTE]) mixed model design was used to assess our second hypothesis concerning intrusive memories, with Group the between subjects factor and Valence the within subjects factor. This hypothesis assessed frequency of positive, negative and neutral intrusive memories between groups. Our third and main hypothesis was assessed using three simple moderation analyses, with one predictor (PCL score), three moderators (Sleep Quality [PSQI score, sleep duration the night before the second session and REM disturbance the night before the second session]) and one outcome variable (number of negative intrusive memories).

**Materials and Measures**

**Pittsburgh Sleep Quality Index (PSQI: Buyesse, et al., 1989).** The PSQI measures subjective sleep quality over the month before scoring. PSQI scores are self-reported on a 19-item questionnaire, with each item describing sleep disturbances rated on a four-point scale ranging from “Not during the past month” to “Three or more times per week” (Appendix B1). The PSQI is reported to have good internal consistency, with a Cronbach’s

alpha of .83 (Buyesse, et al., 1989). We used the PSQI to assess subjective sleep quality, with higher scores on the PSQI indicative of poorer sleep quality.

**Acute Sleep Diary.** A further index of participant sleep quality was obtained using an acute sleep diary, where participants reported hours of sleep on nights before each testing session (Appendix B2).

**REM Behaviour Disorder Screening Questionnaire.** This was an adapted measure of the REM Behaviour Disorder Screening Questionnaire (RBDSQ: Stiasny-Kolster, et al., 2007), a validated subjective measure of REM disturbance with internal consistency scored as Cronbach's alpha of .885 (Stiasny-Kolster, et al., 2007). We used this diary as a measure of REM disturbance and acute sleep duration (Appendix B2).

**PTSD CheckList – Civilian Version (PCL-C: Foa, et al., 1997).** The PCL-C assesses PTSD symptomatology and provides both diagnostic information based on the DSM-IV-TR (American Psychiatric Association, 2000), as well as an ordinal measure of PTSD symptom severity. The PCL-C consists of 17 self-report items, which are rated on five-point Likert scales, ranging from 1 ("Not at all") to 5 ("Extremely"). Each item indicates symptomatology over the past month of intrusive memories, hyperarousal and avoidance behaviours (Appendix B3). Ratings of 3 ("Moderate") or above on each item are considered an endorsement of that PTSD symptom and examination of symptomatology across the measure can provide a DSM-IV-TR diagnosis of PTSD. The PCL-C is reported to have good reliability, with a Cronbach's alpha of .90 (Foa, et al., 1997). The PCL-C was used in this study to assess PTSD status and severity of PTSD symptoms (Appendix B3).

**Traumatic Experiences Questionnaire (TEQ: Vrana & Lauterbatch, 1994).** The TEQ assesses respondents' experiences of events that may be classified as criterion A trauma by the DSM-IV-TR (APA, 2000). The TEQ uses an 11-item, dichotomous answer (yes/no) scale, that also assesses the type of trauma experienced (physical/sexual assault, accidents,

combat, natural disasters, etcetera). The TEQ is reported to be a reliable measure with a Cronbach's alpha of .91 (Vrana & Lauterbatch, 1994). This study used the TEQ to assess trauma exposure (Appendix B4).

**International Affective Picture System Images (IAPS: Lang, Bradley, & Cuthbert, 2008).** According to standardized procedure, 20 emotionally positive images (mean valence: 7.49, mean arousal: 4.42), 20 neutral images (mean valence: 4.99, mean arousal: 2.75) and 20 negative images (mean valence: 2.30, mean arousal: 6.18) were selected to be presented in a counterbalanced design to participants. These images were chosen on the basis of normative data and stimuli from IAPS (Lang, et al., 2008).

**Intrusive Memories Diary (adapted from Holmes, Brewin, & Hennessy 2004).** The intrusive memories diary assessed frequency and distress of intrusive memories of IAPS images following the first testing session. The diary assessed intrusive memories of positive, neutral and negative images (Appendix B5).

**Medical Questionnaire.** Participant medical history was obtained using a basic medical questionnaire. The medical questionnaire included questions pertaining to substance and tobacco use, medication, psychiatric condition and other questions of a medical nature (Appendix B6).

**Depression, Anxiety and Stress Scale (DASS-21: Lovibond & Lovibond, 1995).** The DASS-21 is a short, 21-item questionnaire that uses four-point Likert scales across questions pertaining to the depression, anxiety and stress levels of respondents over the past week (Appendix B7). The questionnaire is self-reported and has good internal consistency for its depression (Cronbach's a = .91), anxiety (a = .84) and stress (a = .90) scales (Lovibond & Lovibond, 1995). The DASS-21 was used in this study to assess current depression, anxiety and stress in participants.

**Alcohol Use Disorders Inventory Test (AUDIT: WHO, 2001).** The AUDIT measures alcohol consumption using a 10-item questionnaire (Appendix B8). The AUDIT is scored by self-report, with each item rated on a five-point Likert scale. The AUDIT has good internal consistency, with a Cronbach's alpha of .83 (Hays, Merz, & Nicholas, 1995). In this study, the AUDIT was used to screen for heavy alcohol use or dependence.

**Procedure**

Two sessions were conducted two days apart (see Figure 5). Sessions were conducted in the afternoon, which was a requirement of salivary measures used in the broader testing protocol (not reported in the current study). Informed consent was obtained in the first session. Participants completed the DASS-21, the PCL-C and the TEQ, so that they could be grouped into NTE, TE or PTSD groups. To prevent priming or rehearsing which may corrupt the memory task, participants were informed that the purpose of the study was to examine the impact of arousal on viewing images and they were unaware that the study examined memory until the second session. Participants were placed in front of a laptop computer, where they were shown blocks of IAPS images (60 total, 20 negative, 20 neutral and 20 positive). Each image appeared for six seconds, and the blocks were counterbalanced between participants. After viewing the images, participants completed the medical questionnaire, the AUDIT, the PSQI and a sleep diary for the prior night.

Two days later, participants returned for a follow-up session. Participants recorded the number and nature of intrusive memories of IAPS images viewed two days earlier in the intrusive memory diary. They then completed a second copy of the sleep diary for the night preceding the second session. Finally, participants rated all 60 IAPS images in terms of arousal and valence, as per standard procedure (Lang, et al., 2008). They were subsequently thanked for their time, debriefed fully on the goals of the study, and reimbursed in monetary payment or course credits.

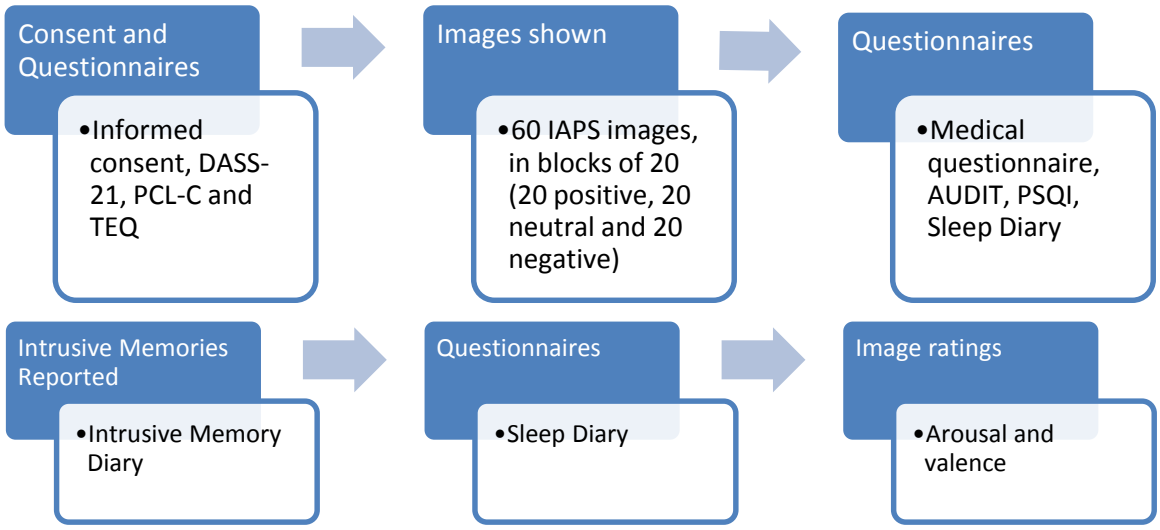


*Figure 5.* Sessions one and two of experiment

**Analysis**

Gender differences between groups were analyzed using 3 x 2 Chi Square test of independence. Age and questionnaire scores between groups were assessed using univariate analyses of variance (ANOVA), and followed up with Sidak post-hoc analyses. Univariate ANOVAs and post-hoc analyses were used to test our first hypothesis, by comparing sleep quality scores between groups on our three sleep measures. Our second hypothesis was analyzed using a 3 (Group: PTSD, TE, HC) x 3 (Valence: negative, positive, neutral) mixed model repeated measures ANOVA, with frequency of intrusive memories as the outcome variable. Post-hoc analyses were conducted using Sidak adjusted pairwise comparisons, and statistical significance was set at $p<.05$. 95% confidence intervals (CIs) and effect sizes were reported. $R^2$ and $\Delta R^2$ were used as measures of effect size for moderation analyses (Field, 2013). In the case of sphericity in the data, Greenhouse-Geisser (GG) corrections were applied.

Our final hypothesis was assessed using a simple moderation analysis, with significant interaction effects investigated using simple slopes and the Johnson-Neyman

technique (Johnson & Neyman, 1936; Preacher, Curran, & Bauer, 2006). These analyses were conducted using Andrew Hayes's PROCESS macro v2.16 for SPSS 23 (Hayes, 2016). Moderation is said to occur when a predictor variable's (X's) effect on an outcome (Y) depends on the value of a third variable (known as the moderator, M; see Figure 6).

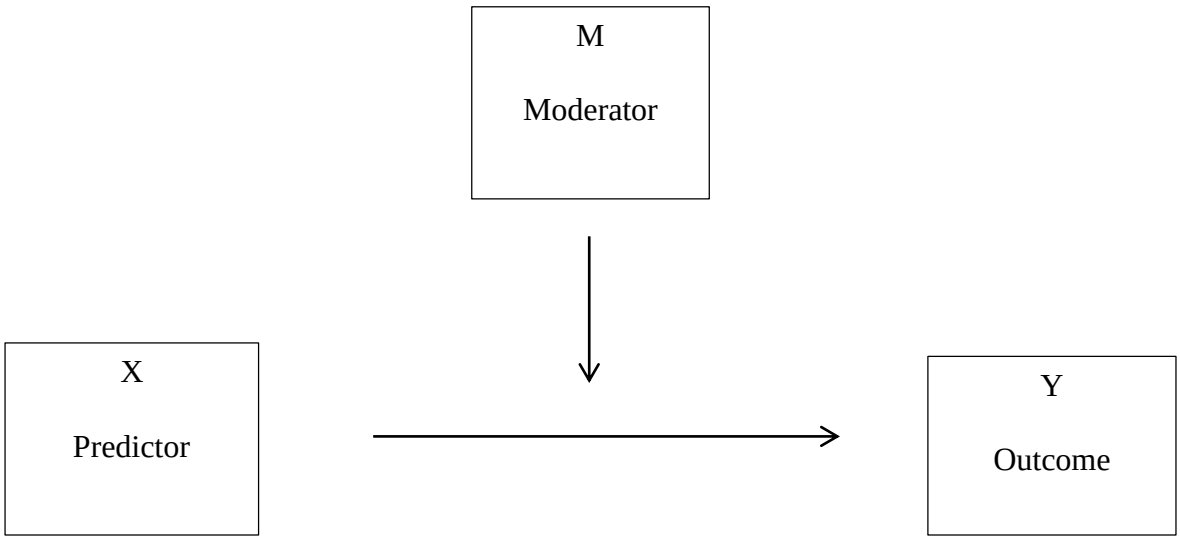


*Figure 6.* The strength or direction of the effect of X on Y depends on M.

Moderation is considered to be a regression equation with three coefficients:

$$Y = i + b_1X + b_2M + b_3XM + e_Y$$

Therefore, although moderation may be theoretically depicted as in Figure 6, algebraically it is most similar to that depicted in Figure 7. In moderation, the outcome is regressed on both the predictor and the moderator separately, while either the predictor or moderator is set at zero. This means that both X's and M's independent effects on Y are not main effects, instead they are known as conditional effects (Hayes, 2013). The emphasis in moderation is instead on the interaction effect of X and M on the outcome. If this interaction is significant, then moderation is said to occur (Hayes, 2013). Simple slopes analyses are used to establish at what values of the moderator the effect of X on Y is significant (these values are usually arbitrarily determined as one standard deviation above and below the

mean, see Hayes & Mattes, 2009). The Johnson-Neyman technique (Johnson & Neyman, 1936) is a promising avenue for depicting with more precision at what values of the moderator the effect of X on Y exists (Hayes, 2013; Hayes & Matthes, 2009; Preacher, et al., 2006).

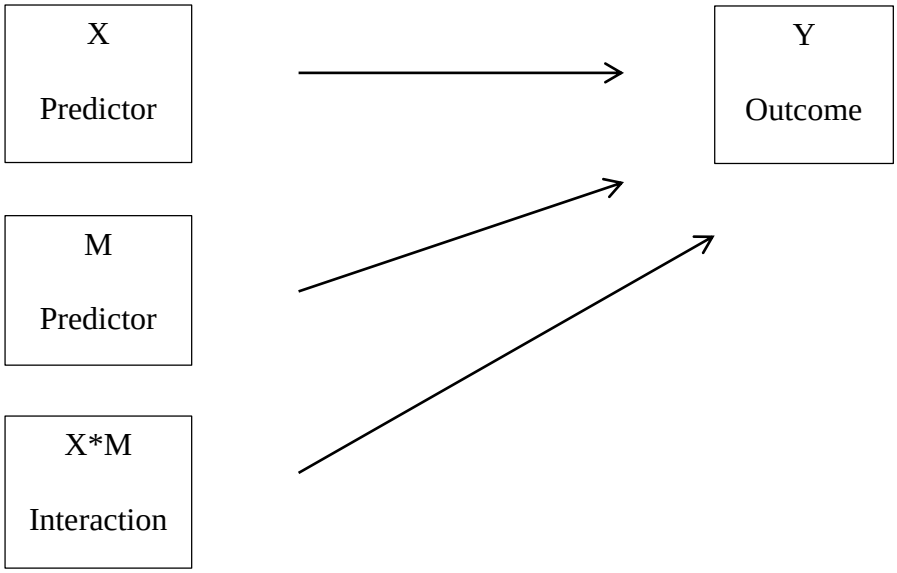


*Figure 7.* Moderation models consider the effects of the predictor, the moderator and the predictor-moderator interaction on the outcome

In our analysis, the predictor variable was PTSD symptomology as measured by PCL total score, the moderator was sleep quality (measured by the PSQI, hours of sleep before the second session and REM disturbance before the second session) and the outcome was negative intrusive memory frequency. We used bias-corrected bootstrapping with 10,000 resamples in our analysis, which is provided as part of the PROCESS macro (Hayes, 2016). We used mean centered variables to improve the interpretability of our conditional effects (Hayes, 2013) and heteroscedasticity-consistent inference to protect from lack of homoscedasticity (Hayes & Cai, 2007).

## Results

Data were screened for missing values. Eight participants were removed for incomplete data. PCL, sleep duration before session two (HRS2) and REM disturbance before session two (REM2) were missing one value each. Due to the large sample size, these missing values were replaced using the replace missing values with linear trend at point function on SPSS (Tabachnick & Fidell, 2001). Nine controls (TE = 7, NTE = 2) were also removed due to current depression and medication use. Using the ±3 standard deviation rule, seven univariate outliers were detected and replaced with values inside three standard deviations of the mean (Tabachnick & Fidell, 2001). Multivariate outliers were screened for using criteria of violating at least two of Mahalanobis's distances, Cook's distances and leverage values (Tabachnick & Fidell, 2007). One multivariate outlier was detected and removed, leaving us with a sample of 118 participants (40 NTE, 44 TE and 34 PTSD).

Skewness, kurtosis and normality plots were assessed using frequency distribution histograms for all variables. Normality was corrected on all DASS variables, AUDIT, PSQI and REM2 using square root transformations, and PCL scores using natural log transformation (Tabachnick & Fidell, 2001). This yielded adequate overall normality, no multicollinearity between variables and a good Durbin-Watson score of 1.94. Despite our best efforts, we were not completely satisfied with the linearity and homoscedasticity of our data, which was likely due to the smaller PTSD group and underreporting of intrusive memories. A correlation matrix (Appendix D1) provided reason to control for DASS-Stress, since it was correlated with intrusive memories, the sleep data and the other DASS scales (Hayes, 2013). Although some previous research has suggested a role of smoking in intrusive memories (Hawkins & Cougle, 2013), we chose not to include smoking as a covariate since it was unrelated to intrusive memories in our sample (Hayes, 2013).

**Demographic and Clinical Data**

Mean scores and standard deviations, as well as univariate ANOVA test statistics, are summarized in Table 1 for demographic and clinical data across NTE, TE and PTSD groups. Gender distribution between groups was statistically equal; however, age, AUDIT, DASS, PCL and TEQ scores were all significantly different between groups. Sidak post-hoc analyses (see Appendix D2) indicated that PTSD participants scored higher than TE and NTE participants on measures of stress, PTSD symptoms and traumatic experiences. PTSD participants were significantly older than NTE participants and TE participants. TE participants scored higher on measures of stress, PCL and TEQ scores than NTE participants (see Appendix D2).

Table 1

*Demographic and Clinical Data for PTSD and Control Groups.*

| | NTE (*n*=40) | TE (*n*=44) | PTSD (*n*=34) | Total (*N*=118) | Test Statistic (DoF) | *p* | Effect size |
|---|---|---|---|---|---|---|---|
| Age | 23.00(7.48) | 25.84(8.78) | 31.79(14.66) | 26.59(10.96) | $F(2,115) = 6.67$ | .002 | $\eta_p^2 = .10$ |
| Gender | 24F, 16M | 23F, 21M | 19F, 15M | 66F, 52M | $\chi^2(2) = .51$ | .776 | $\varphi_c = .07$ |
| DASS^ -stress | 3.55(2.95) | 5.86(3.83) | 11.50(5.15) | 6.70(5.11) | $F(2,115) = 37.73$ | <.001 | $\eta_p^2 = .34$ |
| PCL^ | 21.28(4.94) | 26.20(5.81) | 49.29(11.47) | 31.19(14.00) | $F(2,115) = 137.82$ | <.001 | $\eta_p^2 = .71$ |
| TEQ | .45(.85) | 2.83(1.64) | 4.42(1.86) | 2.48(2.18) | $F(2,) = 66.52$ | <.001 | $\eta_p^2 = .54$ |

*Note: n* = number of group participants, *N* = number of total participants. ^Means and standard deviations reflect untransformed data. Test statistics, significance levels and effects sizes reflect transformed data.

**Image Ratings**

For arousal and valence ratings of IAPS images, 3 (Group) x 3 (Image Valence) repeated measures were used (for means and standard deviations, see Appendix D3).

**Valence.** Figure 8 illustrates mean participant valence ratings for IAPS images. There was a significant main effect of valence (neutral, positive, negative; [$F(2,117) = 342.61$, $p<.001$, $\eta_p^2 = .75$], but not of group [$F(2,117) = .50$, $p = .609$, $\eta_p^2 = .01$]. Post-hoc analyses suggested that neutral images were rated less negative than negative images ($p < .001$) and less positive than positive images ($p < .001$). Positive images were rated less negative than negative images ($p < .001$). As can be observed in Figure 8, PTSD participants rated positive images less positive and negative images less negative than the control groups. This interaction between group and image valence nearly reached significance [$F(4,234) = 2.37$, $p = .054$, $\eta_p^2 = .04$], but no significant differences between group ratings of any image valence were observed post-hoc.

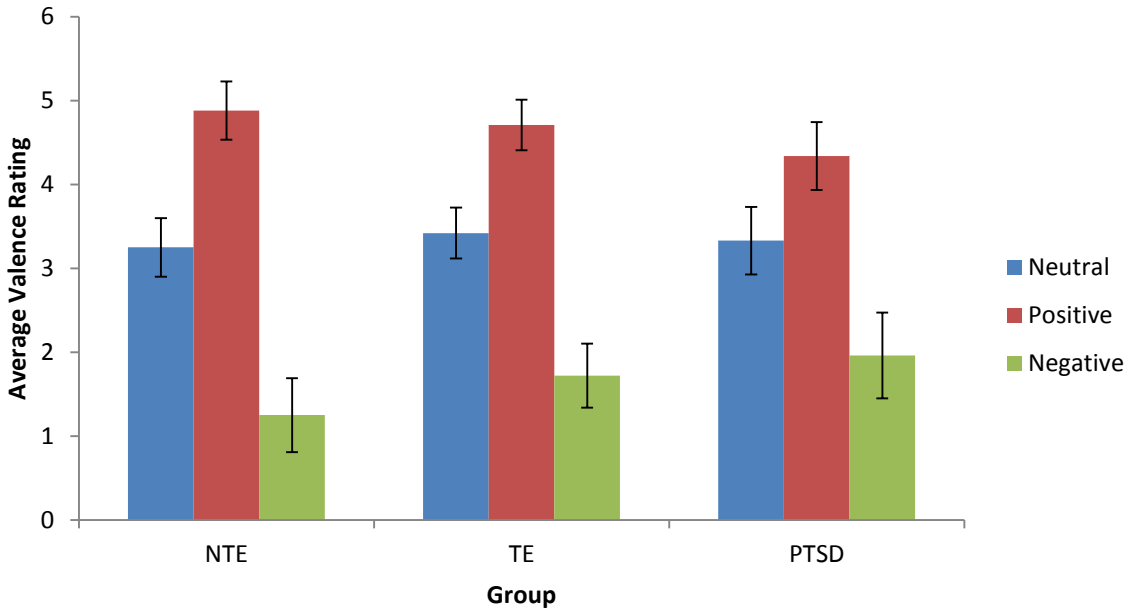


*Figure 8.* Mean IAPS image participant valence ratings by NTE, TE and PTSD groups

*Note:* Error bars: 95% Confidence Intervals. Neutral rating = 5, most negative rating = 1, most positive rating = 9.

**Arousal.** Figure 9 illustrates the mean participant arousal ratings for IAPS images between NTE, TE and PTSD groups. There was a main effect of image valence [GG corrected $F(1.91,223.62) = 307.81$, $p < .001$, $\eta_p^2 = .73$], but not of group [$F(2,117) = .44$, $p = .643$, $\eta_p^2 = .01$]. Post-hoc analyses suggested that neutral images were rated less arousing than both negative (p <.001) and positive (p <.001) images, and that positive images were rated less arousing than negative images (p <.001). The group x valence interaction was non-significant for arousal ratings [GG corrected $F(3.82, 223.62) = 1.80$, $p = .129$, $\eta_p^2 = .03$].

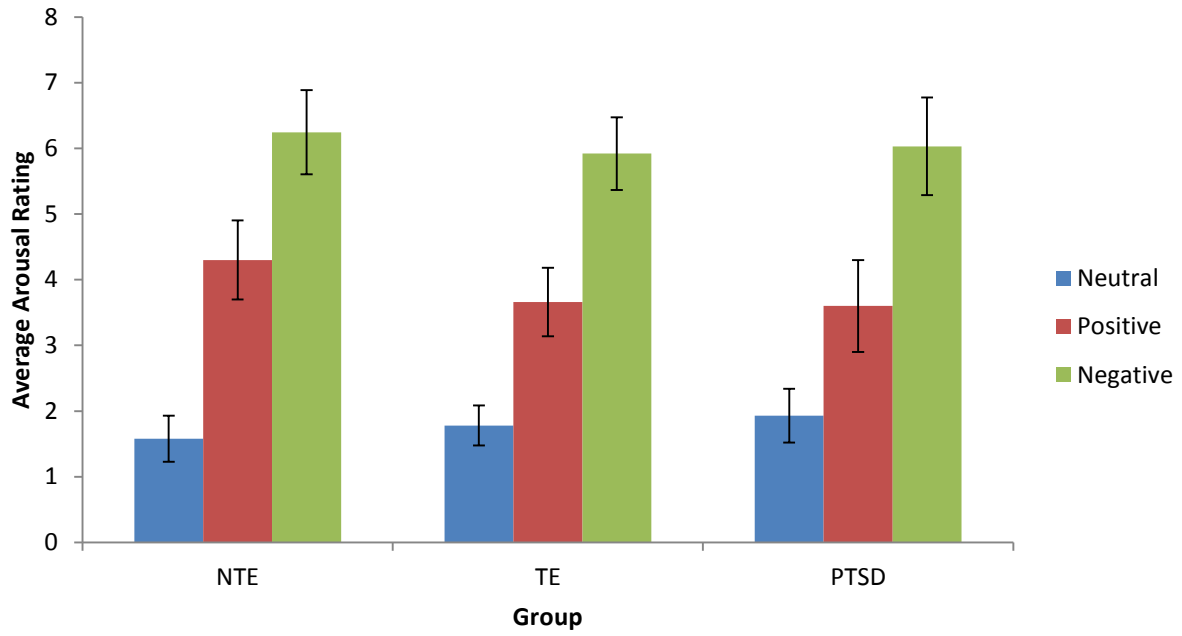


*Figure 9.* Mean IAPS image participant arousal ratings by NTE, TE and PTSD groups

*Note:* Error bars: 95% Confidence Intervals. Neutral arousal rating = 1, most aroused rating = 9.

## Sleep Data

Central tendency data and univariate ANOVA test statistics for PSQI, hours slept before second session and REM disturbance before second session for each group can be found in Table 2. There was a significant main effect of group on all three sleep measures. .

Table 2

*Summary of Sleep Data on the Pittsburgh Sleep Quality Index, Hours of Sleep and REM Disturbance*

| Measure | NTE (*n*=40) | TE (*n*=44) | PTSD (*n*=34) | Total (*N*=118) | *F*(DoF) | *p* | Effect size $\eta_p^2$ |
|---|---|---|---|---|---|---|---|
| PSQI | | | | | | | |
| -Total | 4.45 (2.38) | 5.77 (2.40) | 9.18 (4.06) | 6.31 (3.51) | 24.71(2,115) | <.001 | .30 |
| Hrs Sleep | | | | | | | |
| -Session 2 | 7.54 (1.34) | 7.78 (1.25) | 6.60 (1.93) | 7.36 (1.57) | 6.43(2,115) | .002 | .10 |
| REM disturbance^ | | | | | | | |
| -Session 2 | 3.33 (4.46) | 4.61 (5.07) | 10.66 (9.43) | 5.92 (7.12) | 10.58(2,115) | <.001 | .16 |

*Note:* ^ *F* Statistic, Significance Level and Effect Size reflect transformed data.

Sidak post-hoc analyses showed that PTSD participants scored poorer sleep quality than NTE ($p$ <.001, 95% CI [.60, 1.25]) and TE groups ($p$ <.001, 95% CI [.29, .92]) on the PSQI; than NTE ($p$ =.024, 95% CI [-1.80, -.10]) and TE participants ($p$ =.002, 95% CI [-2.02, -.36]) on hours of sleep before the second session; and, than NTE ($p$ <.001, 95% CI [.69, 2.34]) and TE participants ($p$ =.002, 95% CI [.34, 1.96]) on REM disturbance before the second session. NTE and TE groups did not differ on hours slept ($p$ =.848, 95% CI [-1.04, .56]) or REM disturbance before the second session ($p$ =.582, 95% CI [-1.14, .41]), but TE participants had higher PSQI scores than NTE participants ($p$ =.033, 95% CI [.02, .62]), indicative of poorer sleep.

**Intrusive Memory Data**

Figure 10 illustrates the mean positive, negative and neutral intrusive memories for NTE, TE and PTSD groups (for means and standard deviations, see Appendix D4). A 3 (Group) x 3 (Valence) repeated measures ANOVA showed a significant main effect of image valence [$F(2,230) = 36.10$, $p < .001$, $\eta_p^2 = .24$], indicating that participants had different numbers of intrusive memories of positive, negative and neutral images. Post-hoc analyses showed there were significantly more negative intrusive memories reported than positive ($p < .001$, 95% CI [.25, .60]) and neutral ($p < .001$, 95% CI [.35, .70]) intrusive memories. There was no difference between number of positive and neutral intrusive memories ($p = .137$, 95% CI [-.02, .22]).

There was also a significant main effect of group [$F(2,115) = 8.64$, $p < .001$, $\eta_p^2 = .13$], such that PTSD participants reported more intrusive memories than NTE participants ($p < .001$, 95% CI [.16, .59]), but not TE participants ($p = .146$, 95% CI [-.04, .39]). TE participants reported close to significantly more intrusive memories than NTE participants ($p = .059$, 95% CI [-.005, .404]).

The main effects of group and image valence were superseded by a significant group x valence interaction [$F(4,230) = 8.82$, $p < .001$, $\eta_p^2 = .13$]. Post-hoc analyses showed that PTSD participants scored significantly more negative intrusive memories than NTE participants, as judged by 95% CI overlap (PTSD 95% CI [.75, 1.31], NTE 95% CI [-.16, .36]). TE scored nearly more negative intrusions than NTE participants (TE 95% CI [.32, .81]), and nearly significantly less intrusions than PTSD participants. Interactions of other valences were not significant.

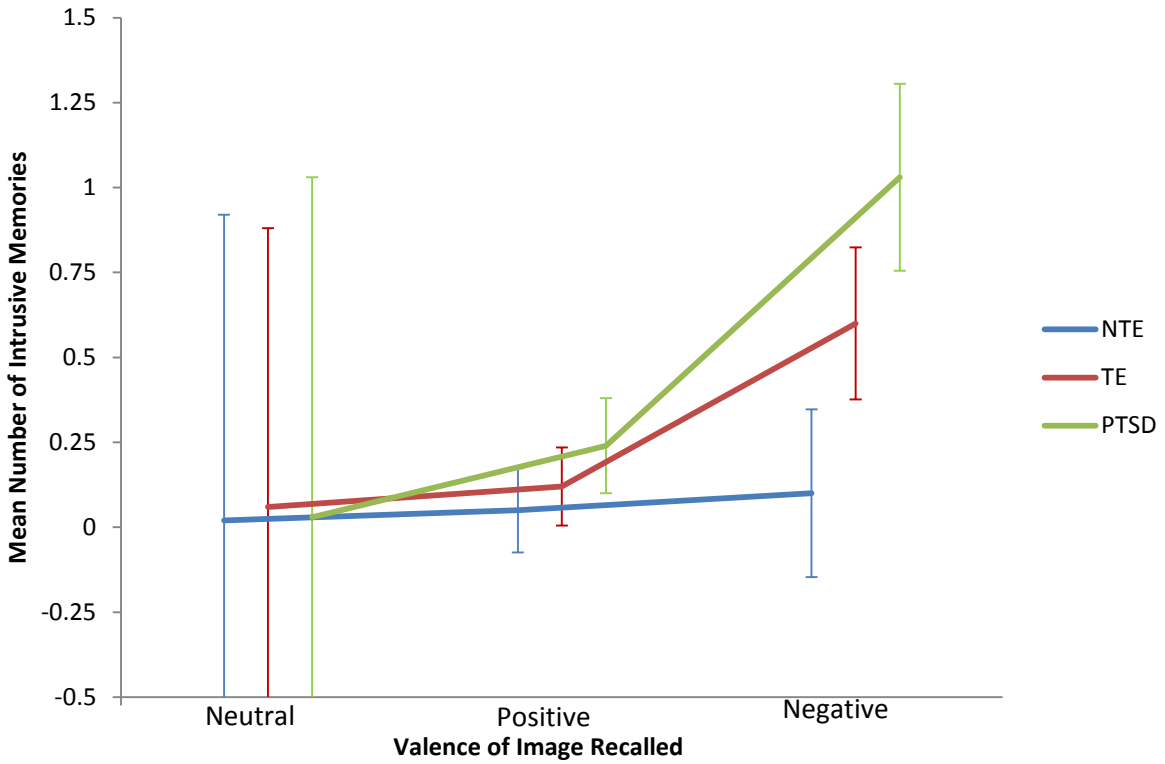


*Figure 10.* Mean number of neutral, positive and negative intrusive memories for NTE, TE and PTSD groups. Error bars: 95% Confidence Intervals

**Moderation Analyses**

Moderation analyses using PROCESS (Hayes, 2016) were conducted to test the relationship between PCL scores and intrusive memory frequency, as moderated by three different measures of sleep quality. The following results depict the conditional and interaction effects for each measure of sleep in the assessment of possible moderation effects.

**PSQI.** PSQI score was not a significant moderator of the PCL-intrusive memory relationship [$F(1,114) = .76$, $p = .384$, $\Delta R^2 = .004$]. Table 3 contains the regression coefficients for all predictors of negative intrusive memories in the model. PSQI score was a non-significant predictor of intrusive memories, but PCL scores predicted negative intrusions as a conditional effect, such that higher PCL scores were associated with more intrusions. Since the interaction effect was not significant, simple slopes were not assessed.

Table 3

*Summary Statistics for the Moderating Effect of PSQI Score*

| | | | | | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|
| | *b* | SE | *t* | *p* | Lower bound | Upper bound |
| constant | .51 | .09 | 5.48 | <.001 | .33 | .70 |
| PCL^ | .58 | .27 | 2.13 | .035 | .04 | 1.12 |
| PSQI^ | .25 | .18 | 1.39 | .166 | -.10 | .60 |
| PCL^*PSQI^ | .19 | .21 | .87 | .384 | -.23 | .61 |

*Note:* ^ coefficients, standard errors, *t*-statistics, significance levels and confidence intervals reflect analyses performed on transformed data. Overall model: $F(3,114) = 8.37$, $p < .001$, $R^2 = .18$

**Hours of Sleep before Second Session**. The moderating effect of hours of sleep before the second session on the PCL – intrusive memory relationship was nearly significant [$F(1,114) = 3.89$, $p = .051$, $\Delta R^2 = .025$]. Table 4 contains the regression coefficients for all predictors of negative intrusive memories in this model. Again, PCL scores produced a significant conditional effect as a predictor of intrusive memories; however, the HRS2 x PCL interaction was very nearly significant, indicating a negative relationship between hours of sleep, PCL score and intrusive memories.

Table 4

*Summary Statistics for the Moderating Effect of Hours of Sleep before the Second Session*

| | | | | | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|
| | *b* | se | t | p | Lower bound | Upper bound |
| constant | .49 | .08 | 5.91 | <.001 | .33 | .66 |
| PCL^ | .66 | .20 | 3.35 | .001 | .27 | 1.05 |
| HRS2 | -.04 | .05 | -.78 | .435 | -.13 | .06 |
| PCL^*HRS2 | -.23 | .11 | -1.97 | .051 | -.452 | .001 |

*Note:* ^ coefficients, standard errors, *t*-statistics, significance levels and confidence intervals reflect analyses performed on transformed data. Overall model: $F(3,114) = 8.02$, $p < .001$, $R^2 = .19$

Simple slopes analyses, visualized in Figure 11, indicated that for those who slept the longest the night before the second session (one or more standard deviations above the mean), there not an association between PCL score and intrusive memories. That is, for high sleep scores, PCL $b$ = .30, $t(114)$ = .97, $p$ = .335; for average sleep scores, PCL $b$ = .66, $t(114)$ = 3.33, $p$ = .001; and for low hours of sleep, PCL $b$ = 1.01, $t(114)$ = 4.74, $p$ <.001.

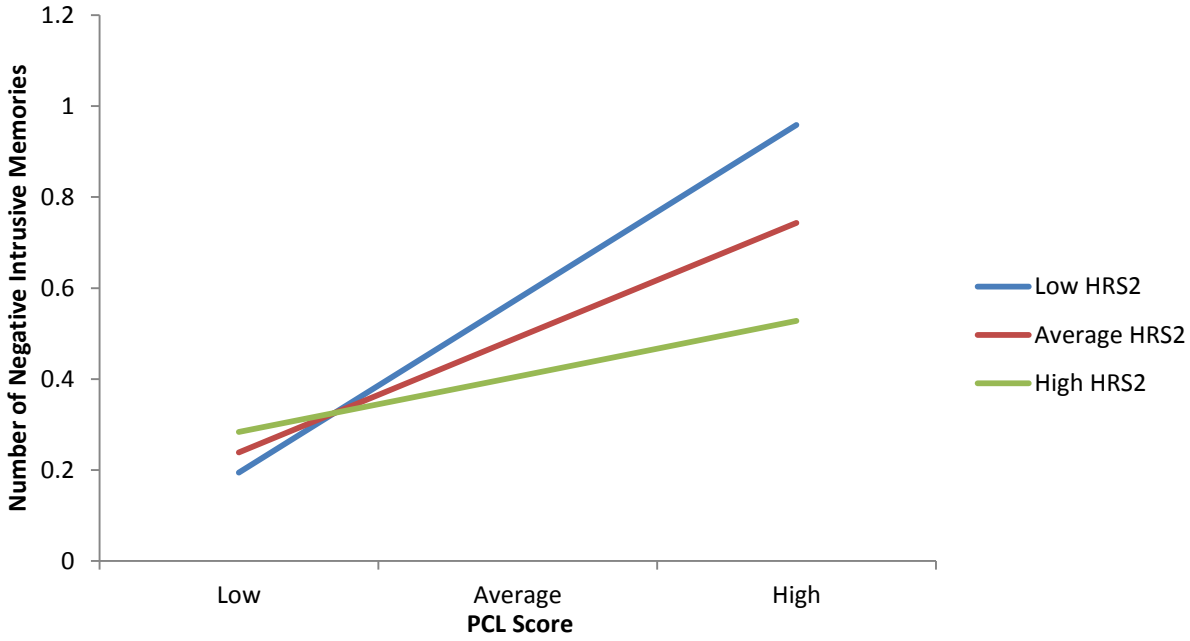


*Figure 11.* Mean number of intrusive memories for low, average and high PCL scores depended on hours of sleep before the second session

In addition to simple slopes, Johnson-Neyman tests were conducted, revealing that for hours of sleep above a threshold of 8.13 hours, the conditional effect of PCL score on number of intrusive memories was non-significant at $p$ >.05. With less than 8.13 hours sleep before the second session, PCL and negative intrusive memory frequency were significantly related [$t(114)$ = 1.98, $p$ =.050, $b$ =.48]. As hours of sleep before the second session decreased, the positive association between PCL score and negative intrusive memory frequency grew stronger: Participants who slept 6 hours, $b$ = .96, $t(114)$ = 4.76, $p$ <.001, an effect that retained significance until the fewest hours slept [3 hours, $b$ = 1.64, $t(114)$ = 3.52, $p$ = .001].

Sleep scores above 8.13 hours before the second session represented 32.20% of the sample, compared to 67.80% below this threshold.

**REM Disturbance before Second Session.** The moderating effect of REM disturbance before the second session on the PCL – intrusive memory relationship was not significant [$F(1,114) = 1.93$, $p = .168$, $\Delta R^2 = .014$]. Table 5 contains the regression coefficients for all predictors of negative intrusive memories in the model. REM disturbance before the second session did not independently predict intrusive memories, but PCL score again positively predicted negative intrusions.

Table 5

*Summary Statistics for the Moderating Effect of REM Disturbance before the Second Session*

| | | | | | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|
| | *b* | SE | *t* | *p* | Lower bound | Upper bound |
| constant | .50 | .08 | 6.12 | <.001 | .34 | .66 |
| PCL^ | .62 | .20 | 3.13 | .002 | .23 | 1.01 |
| REM2^ | .10 | .06 | 1.51 | .133 | -.03 | .22 |
| PCL^*REM2 | .17 | .12 | 1.39 | .168 | -.07 | .41 |

*Note:* ^ coefficients, standard errors, *t*-statistics, significance levels and confidence intervals reflect analyses performed on transformed data. Overall model: $F(3,114) = 7.30$, $p < .001$, $R^2 = .20$

**Covariate Effect of Stress**

All three analyses were replicated with DASS-Stress as a covariate, since this measure correlated with DASS-Depression and DASS-Anxiety, the sleep measures and the dependent variable (Appendix D5 – D9; Hayes, 2013). Small differences were observed in the sleep data, with PTSD and NTE groups not being significantly different in hours slept before the second session. Further, the difference between TE and NTE negative intrusive memories was more distinct (TE 95% CI [.33, .82], NTE 95% CI [-.15, .42]). No other

changes in sleep or intrusive memory data were observed. Effect sizes in moderation analyses did not vary when DASS-Stress was statistically controlled, but the hours of sleep moderation was significant at $p$ =.048 (Appendix D7 – D9).

**Effect of Medication**

Sleep data was rerun with medicated participants removed (defined as using anti-depressants, benzodiazepines or sleep agents; PTSD $n$ = 5). No differences were observed in the sleep data when medicated participants were removed (Appendix E1 – E2). Similarly, there were no differences in the main effects of intrusive memory data, though there were nearly significantly more positive than neutral intrusive memories ($p$ = .053, 95% CI [-.247, .001]). There was a smaller difference between number of PTSD and TE reported intrusions ($p$ = .248, 95% CI [-.07, .38]). All interactions remained the same (Appendix E3).

Moderation analyses were also rerun with medicated participants removed ($n$ = 5, see Appendix E4 – E6). With these participants removed, interaction effects were not significant when PSQI was the moderator [$F(1,109) = 1.17$, $p$ = .282, $\Delta R^2$ = .006], when hours of sleep was the moderator [$F(1,109) = 2.02$, $p$ = .158, $\Delta R^2$ = .014] or when REM disturbance was the moderator [$F(1,109) = 1.52$, $p$ = .220, $\Delta R^2$ = .013]. Since none of the interaction effects were significant, no further tests were run. Comparison of means revealed that medicated and unmedicated participants differed on number of negative intrusive memories, but only marginally on hours of sleep before the second session or PCL score (Table 6).

Table 6

*Differences between Medicated and Unmedicated PTSD Participants on Negative Intrusive Memories, PCL score and Hours of Sleep Before the Second Session*

| | Medicated (*n* = 5) | Unmedicated (*n* = 29) | *F* Statistic (DoF) | *p* |
|---|---|---|---|---|
| Mean Negative Intrusive Memories (SD) | 1.40 (1.14) | .97 (1.15) | .61 (1,32) | .440 |
| PCL score^ | 51.40 (13.85) | 48.93 (11.26) | .19 (1,32) | .664 |
| HRS2 | 6.25 (2.58) | 6.66 (1.84) | .18 (1,32) | .674 |

^analyses performed on transformed data

## Discussion

The present study investigated the relationship between sleep quality (scored on the PSQI, hours of sleep and REM disturbance before the second session) and intrusive memories in non-trauma exposed (NTE), trauma exposed (TE) and PTSD participants. We found that PTSD participants reported significantly higher sleep disturbance, reflected in measures of the PSQI, hours of sleep and REM disturbance prior to the memory recall session. Further, PTSD participants reported more negative intrusive memories than NTE group, with the TE group between these groups. Moderation analyses revealed that while subjective measures of sleep quality (PSQI, REM disturbance) did not significantly moderate the relationship between PTSD symptoms and number of negative intrusive memories, hours of sleep produced a near-significant moderating effect, such that PTSD symptoms were significantly associated with negative intrusions only when there were lower hours of sleep the night preceding the memory test. These findings provide some support for the Sleep to Forget, Sleep to Remember approach to intrusive memories in PTSD (Walker, 2009).

**Sleep Quality Data**

We used three separate sleep measures to assess different aspects of sleep, including perceptions of sleep quality (PSQI), self-report of REM behavior and hours of sleep before the second session. We did this because different aspects of sleep have different functions. For instance, REM sleep quality may represent a biological state important for emotional memory consolidation (Germain, 2013; Goldstein & Walker, 2014; Stickgold, 2002). Conversely, non-specific sleep duration may be unrelated to REM disturbances, though is indicative of poorer memory (Rasch & Born, 2013) and psychiatric symptoms in different disorders (Baglioni, et al., 2016). Finally, the PSQI combines a number of different sleep quality indicators to give a general overview of subjective sleep quality, though these domains do not assess REM behavior specifically (see Appendix B1).

As predicted in our first hypothesis, PTSD participants scored significantly poorer than control participants across all three measures of sleep. Our findings support previous findings that individuals with PTSD experience poorer overall sleep quality (Germain, 2013; Kobayashi, et al., 2007; Maher, et al., 2006), abnormal REM sleep (Germain, 2013; Kobayashi, et al, 2007; Mellman, et al., 2014) and difficulties sleeping (Harvey, Jones, & Schmidt, 2003; Kobayashi, et al., 2007). In the current analyses, the effect sizes for sleep differences were largest when stress was not controlled for; this was likely due to high correlations between DASS measures and PCL scores, rather than to a genuine effect of stress on the quality of sleep in our sample (see Appendix D1).

**Intrusive Memory Data**

A main effect of valence in our analysis of intrusive memory data indicated that negative intrusive memories were experienced more frequently than intrusive memories of positive or neutral stimuli. This result confirms a well-established finding in the emotional

memory literature of greater memory intrusions to negative stimuli (Kleim, et al., in press; Nicholson, Felmingham, & Bryant, 2014).

Intrusive memories of traumatic events in PTSD are experienced in a highly distressing and realistic way (APA, 2013; Ehlers, 2010). Theoretical models propose that intrusive memories in PTSD develop due to extreme arousal during encoding which results in a lack of contextualization and consolidation of traumatic memories into autobiographical memory (Brewin, et al., 2010; Conway & Pleydell-Pearce, 2000; Ehlers & Clark, 2000; Nicholson, et al., 2014; Pitman & Delahunty, 2005). In this study, we predicted that PTSD participants would report significantly more negative intrusive memories than controls. This hypothesis was largely confirmed as the PTSD group reported significantly more negative intrusions than the NTE group, and more negative intrusions than TE participants at a trend level. There was also a trend towards significance in the difference between TE and NTE negative intrusions.

Theoretically, we may have expected TE participants to report a high number of negative intrusive memories, since trauma exposure impacts neurobiological processes (Nemeroff, 2004; Rincon-Cortes & Sullivan, 2014; Stark, et al., 2015) and memory (Chou, La Marca, Steptoe, & Brewin, 2014). Our results therefore support a dimensional approach to trauma exposure and PTSD development (Stark, et al., 2015). That the PTSD group failed to experience more intrusive memories than both control groups may also reflect a floor effect of intrusive memories in our study. This floor effect has been discussed in other studies (Nicholson, et al., 2014; Werner, et al., 2015; Wiesner, et al., 2015), where use of IAPS images has not created a strong or enduring enough reaction simulating actual trauma. However, it is ethically untenable to increase the arousal of participants to a level of which they feel genuinely traumatized.

**The Moderating Effect of Sleep on the PTSD-Intrusive Memory Relationship**

Our final hypothesis concerned the moderation of the relationship between PTSD symptomology and intrusive memories by our three measures of sleep quality. We predicted that participants with high sleep quality would be protected from intrusive memories, regardless of their PTSD symptomology; whereas participants with poorer sleep quality would not experience this buffering effect. We ran three moderation analyses, each using a measure of sleep quality as a moderator. We did not find a significant interaction effect for any of these analyses. However, hours of sleep before the second session produced a near-significant interaction with PCL score ($p$ =.051). Simple slopes analysis revealed that, for participants with high hours of sleep before the second session, there was not a significant relationship between PTSD symptomology and reported negative intrusions. Conversely, for participants with average or low hours of sleep before the second session, there was a significant relationship between PTSD symptomology and negative intrusions.

Statistically, we may have expected a larger moderation effect had the group sizes been equal (Rosenthal & Rosnow, 2008), since there were relatively few PTSD cases ($n$ = 34) to controls ($n$ = 84). Therefore, although we achieved an adequate sample for .8 power, the sample was mostly representative of the healthy population and not properly reflective of a PTSD sample (Rosenthal & Rosnow, 2008). Nevertheless, our relatively small (and likely underestimated) $R^2$ change of .025 for hours of sleep as a moderator was very nearly significant, considering the size of the effect of the overall model.

Johnson-Neyman output (Johnson & Neyman, 1936) is automatically provided by the latest version of PROCESS for SPSS (Hayes, 2016). The Johnson-Neyman technique allows the user to pinpoint at what level of the moderator the relationship between the predictor and outcome variables becomes significant. In our analysis, 67.80% of our sample slept 8.13 hours or less before the second session. These participants became increasingly susceptible

to experiencing intrusive memories of negative images if they had higher PTSD symptomology. Conversely, participants who slept 8.13 hours or more before the second session did not have a relationship between PTSD symptomology and intrusive memories, as may have been expected had we considered the PTSD – intrusive memory relationship exclusively. Due to an insufficient sample size, we are unable to conclude that 8.13 hours sleep has any substantial meaning for the general population. In our study, this number therefore only serves as a threshold providing evidence of a buffering effect of sleep.

These results support our hypothesis that there would be a moderating effect of sleep quality on intrusive memory development. According to the Sleep to Forget, Sleep to Remember model (Walker, 2009), healthy sleep simultaneously de-potentiates the emotional charge of emotional memories, whilst enhancing the semantic memory for those events. Researchers have thus suggested that sleep disturbances underlie intrusive memories in PTSD, since sleep performs a pivotal role in the consolidation of emotional memories (Germain, 2013; Kleim, et al., in press; Spoormaker & Montgomery, 2008; Stickgold, 2002). Our results seem to align with this approach, since our participants were protected from intrusive memories of negative images if they slept well the night before the second session, regardless of their PTSD status.

Removing medicated PTSD participants ($n$ = 5) as part of a sensitivity analysis saw a reduction of this effect. Medication status may therefore have impacted our results significantly. An alternative explanation for this reduction of effect size was a loss of power due to unequal sample sizes between the PTSD group ($n$ = 29) and controls ($n$ = 84). Unequal sample sizes reduces the ability to detect the significance of an effect (Rosenthal & Rosnow, 2008), and removal of these cases may have simply greatened this imbalance, resulting in a loss of power. Our follow-up analysis revealed that medicated PTSD participants had more intrusive memories than unmedicated PTSD participants. These

participants were likely to have been receiving treatment for more severe cases of PTSD. It is therefore difficult to conclude that loss of the effect was due to the effect of medication. Regardless, our results should be interpreted with caution and future studies should ensure there is a larger PTSD population to divorce the effects of medication from psychiatric severity. No difference in effect size was observed when the effect of stress was controlled.

We did not observe a moderating effect of PSQI scores or REM disturbance on the relationship between PTSD symptomology and intrusive memories. These discrepancies may have been due to a number of factors. Firstly, the PSQI may combine aspects of sleep that are unrelated to memory processes described in SFSR (Walker, 2009) or the Dual Representation model of PTSD (Brewin, et al., 2010). As for REM disturbance, a recent study (Kleim, et al., in press) also failed to find an effect of REM disruptions on intrusive memories, but found an effect of REM density, which represents a distinctly different construct (Kobayashi, et al., 2007), as well as stage 2 sleep and time between trauma manipulation and sleep. It seems likely there are mechanisms other than REM sleep involved in intrusive memory development.

## Theoretical Implications

**Sleep to Forget, Sleep to Remember (Walker, 2009).** In SFSR, REM sleep is postulated to biologically facilitate emotional memory consolidation. SFSR thus considers REM sleep integral to the consolidation and de-potentiation of emotional memories (Goldstein & Walker, 2014). This is proposed to occur due to biological mechanisms present during REM sleep, including increased inter-limbic communication facilitated by theta frequencies (Hutchison & Rathore, 2015); decreased noradrenergic levels in limbic areas (McGaugh, 2004; Vazquex & Baghdoyan, 2001); and increased activity in limbic and paralimbic areas of the brain, including the amygdala and hippocampus (Nofzinger, 2005).

Some researchers have found an association between REM sleep and emotional memory (Hu, et al., 2006; Nishida, et al., 2009; Payne, et al., 2012) and reactivity (van der Helm, et al., 2011). However, others have not (Groch, et al., 2013; Werner, et al., 2015; Wiesner, et al., 2015).

Our results align with the recent findings of Kleim and colleagues (in press), who investigated the relationship between intrusive memories and sleep quality. In their study, they used polysomnography, including EEG, EOG, EMG and ECG, to record REM density, REM duration, sleep duration, stage duration and sleep spindles. They found that REM density and time between viewing a trauma film and sleeping predicted intrusive memory development. However, they did not find an association between intrusive memory development and REM duration, which may have been predicted by SFSR (Kleim, et al., in press). We also did not find that intrusive memory development was buffered by REM disturbance, although we only used a self-report index of REM behavior rather than biological and physiological markers. Therefore, although our findings align with Kleim and colleagues (in press), results must be interpreted with caution. However, de-emphasis of the role of REM sleep in emotional memory processes may potentially explain why some studies have failed to support SFSR (eg. Baran, et al., 2012; Porcheret, et al., 2015; Werner, et al., 2015; Wiesner, et al., 2015).

Finally, our findings generally support the assertion that poor sleep quality is a potentially etiological factor in PTSD and intrusive memories (Germain, 2013; Spoormaker & Montgomery, 2008). Sleep quality is postulated by SFSR to influence emotional memory processing (Walker, 2009). Independently, leading researchers in the field of PTSD assert that lack of consolidation and contextualization of traumatic experiences into explicit, autobiographical memories results in the development of maladaptive intrusive memories (Brewin, et al., 2010; Ehlers & Clark, 2000). Participants in our study who slept less than

8.13 hours before the memory session had an association between PTSD symptomology and intrusive memories. Unfortunately, we were unable to specify what type of sleep leads to this effect. Future studies may rectify this through the technological options available for measuring different aspects of sleep.

**Limitations and Future Research**

Our study had several limitations. Firstly, we experienced a floor effect on intrusive memory frequency, due to the use of images which, despite their high valence, may not have been threatening enough to elicit high arousal. Future research should consider utilizing the aversive film paradigm, which may provide more realistic stimulation (James, Lau-Zhu, Clark, Visser, Hagenaars, & Holmes, 2016). Similarly, intrusive memories appear to develop over time; and measures that track intrusions over a week or more seem more suitable than the retrospective design we employed (eg. Kleim, et al., in press). The floor effect of intrusive memories presented significant challenges to the linearity and normality of our data, and whilst we analyzed and transformed the data, effect sizes and significance levels should be treated with caution, and the pattern of our findings requires replication.

Importantly, although we found a moderating effect of sleep quality, this does not imply causation. Since our data were cross-sectional, we are unable to rule out the possibility that participants who slept poorly did so because they experienced intrusive memories, which is the reverse of what our hypothesis implies. Future researcher may take advantage of the rapid growth of statistical techniques such as the index of moderated mediation (Hayes, 2015); and with a longitudinal prospective design this problem may be easily assessed.

Finally, the present study relied on self-report for sleep quality measures. Sleep quality – particularly specific sleep quality such as REM disturbance – should ideally be measured using polysomnography (Germain, 2013). Unfortunately, access to a sleep lab or

polysomnography was not available for the present study. Future studies should aim to capture the subtleties of sleep we tried to capture using objective technologies, such as lab-based polysomnography.

## Conclusion

The present study investigated the moderating effect of sleep quality on the relationship between PTSD symptoms and intrusive memories. Key findings were that PTSD participants reported poorer sleep quality on all three measures of sleep, including the PSQI, REM disturbance and hours of sleep before the second session than both control groups. PTSD participants also reported having significantly more intrusive memories of negative images than non-trauma exposed controls, but this effect only trended towards significance between PTSD and trauma exposed controls. We found a moderating effect of sleep quality on the relationship between PTSD symptomology and intrusive memories, such that participants who slept in the highest 32.20% of our sample did not report intrusive memories if they had higher PTSD symptomology. These results emphasize the role of sleep in PTSD (Germain, 2013; Goldstein & Walker, 2014), the potential for sleep-based restoration strategies for the treatment of PTSD (Barr, et al., 2015; Ho, et al., 2016), and, in particular, the role of sleep in the development of intrusive memories in PTSD (Kleim, et al., in press). Our findings also support the cathartic effect of general, but not REM, sleep quality on emotional memories, as described by the Sleep to Forget, Sleep to Remember hypothesis (Walker, 2009). A limitation of the current study was that the exact nature of sleep influencing intrusive memories could not be specified from self-report measures. Future studies should therefore use more objective and precise measures of sleep quality (ie. polysomnography), and utilize the aversive film paradigm rather than emotional images.

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# Appendices

# Appendix A

## Human Research Ethics Committee Approval Letter

Dear Professor Felmingham

Ethics Ref: H0013304
Title: The Effect of Sleep on Emotional Memory and Fear Extinction in PTSD

This email is to confirm that the following amendment was approved by the Chair of the Tasmania Social Sciences Human Research Ethics Committee on 29/4/2016:

- Removal of student investigators Kate Gray and Pippa Cushing, who have completed their research.
- Addition of Honours student Luke Ney.
- Revised Information Sheet and Consent Form for participants with PTSD.
- Revised Information Sheet and Consent Form for control participants.

All committees operating under the Human Research Ethics Committee (Tasmania) Network are registered and required to comply with the National Statement on Ethical Conduct in Human Research (NHMRC 2007, updated May 2015).

This email constitutes official approval. If your circumstances require a formal letter of amendment approval, please let us know.

Should you have any queries please do not hesitate to contact me.

Kind regards
Katherine

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# Appendix B

## Questionnaires

Appendix B1

Pittsburgh Sleep Quality Index

**PITTSBURGH SLEEP QUALITY INDEX**

ID: Mega_____ Date: _____

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month.
Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

BED TIME _____

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

NUMBER OF MINUTES _____

3. During the past month, what time have you usually gotten up in the morning?

GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

HOURS OF SLEEP PER NIGHT _____

***For each of the remaining questions, check the one best response. Please answer all questions.***

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

b) Wake up in the middle of the night or early morning

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

c) Have to get up to use the bathroom

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

d) Cannot breathe comfortably

| Not during the past month _____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

e) Cough or snore loudly

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

f) Feel too cold

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

g) Feel too hot

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

h) Had bad dreams

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

i) Have pain

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

j) Other reason(s), please describe _____

_____

How often during the past month have you had trouble sleeping because of this?

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

6. During the past month, how would you rate your sleep quality overall?

Very good _____

Fairly good _____

Fairly bad _____

Very bad _____

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all _____

Only a very slight problem _____

Somewhat of a problem _____

A very big problem _____

10. Do you have a bed partner or room mate?

No bed partner or room mate _____

Partner/room mate in other room _____

Partner in same room, but not same bed _____

Partner in same bed _____

Appendix B2

Acute Sleep Diaries

**SLEEP DIARY**

**Session 1**

Please answer these questions in relation to your sleep **LAST NIGHT**

ID: Mega_____ Date: _____

1. What time did you go to bed last night?_____
2. How long did it take you to fall asleep (minutes)?_____
3. How many times did you wake up during the night?_____

   If you woke, what time (s) – please write down each time if more than one awakening)

   _____

4. How long did it take you to go back to sleep after each awakening?

   (please answer specifically for each awakening)

   _____

   _____

5. What time did you wake up in the morning? _____
6. What time did you get up in the morning? _____
7. Did you have very vivid dreams last night? YES/NO

   a. If yes, how vivid on this scale: **1 (not at all).....3 moderate ....5 (very).....**_____

8. Did any dreams have an aggressive or action-packed content last night? YES/NO

   a. If yes, how action-packed: **1 (not at all).....3 moderate ....5 (very).....**_____

9. Did the dream contents match your behaviour last night? YES/NO

   a. If yes, how much?: **1 (not at all).....3 moderate ....5 (very).....**_____

**10.** Did your arms and legs move during your sleep last night? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

**11.** Did you almost hurt your bed partner or yourself last night? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

**12.** Did you speak/shout/swear or laugh loudly last night in your sleep? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

**13.** Did you have sudden limb movements or "fights" in your sleep last night? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

**14.** Did you have gestures/complex movements during sleep last night? (e.g. waving, salutes, Waving away mosquitos, falling out of bed?) YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

15. Did your movements awaken you last night from sleep? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

16. After awakening, did you mostly remember the contents of your dreams last night? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

17. Was your sleep disturbed last night ? Yes/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

**SLEEP DIARY**

**Session 2**

Please answer these questions in relation to your sleep **LAST NIGHT**

ID: Mega_____ Date: _____

1. What time did you go to bed last night?_____
2. How long did it take you to fall asleep (minutes)?_____
3. How many times did you wake up during the night?_____

   If you woke, what time (s) – please write down each time if more than one awakening)

   _____

4. How long did it take you to go back to sleep after each awakening?

   (please answer specifically for esch awakening)

   _____

   _____

5. What time did you wake up in the morning? _____
6. What time did you get up in the morning? _____
7. Did you have very vivid dreams last night? YES/NO

   a. If yes, how vivid on this scale: **1 (not at all).....3 moderate ....5 (very).....**_____

8. Did any dreams have an aggressive or action-packed content last night? YES/NO

   a. If yes, how action-packed: **1 (not at all).....3 moderate ....5 (very).....**_____

9. Did the dream contents match your behaviour last night? YES/NO

   a. If yes, how much?: **1 (not at all).....3 moderate ....5 (very).....**_____

**10.** Did your arms and legs move during your sleep last night? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

**11.** Did you almost hurt your bed partner or yourself last night? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

**12.** Did you speak/shout/swear or laugh loudly last night in your sleep? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

**13.** Did you have sudden limb movements or "fights" in your sleep last night? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

**14.** Did you have gestures/complex movements during sleep last night? (e.g. waving, salutes, Waving away mosquitos, falling out of bed?) YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

15. Did your movements awaken you last night from sleep? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

16. After awakening, did you mostly remember the contents of your dreams last night? YES/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

17. Was your sleep disturbed last night ? Yes/NO

a. If yes, how much: **1 (not at all).....3 moderate ....5 (very).....**_____

Appendix B3

PTSD CheckList – Civilian Version

**PTSD CheckList – Civilian Version (PCL-C)**

~~Client's Name:~~ ID: Mega Date: __/__/____

Instruction to patient: Below is a list of problems and complaints that veterans sometimes have in response to stressful life experiences. Please read each one carefully, put an "X" in the box to indicate how much you have been bothered by that problem *in the last month*.

| No. | Response | Not at all (1) | A little bit (2) | Moderately (3) | Quite a bit (4) | Extremely (5) |
|---|---|---|---|---|---|---|
| 1. | Repeated, disturbing *memories, thoughts, or images* of a stressful experience from the past? | | | | | |
| 2. | Repeated, disturbing *dreams* of a stressful experience from the past? | | | | | |
| 3. | Suddenly *acting* or *feeling* as if a stressful experience *were happening* again (as if you were reliving it)? | | | | | |
| 4. | Feeling *very upset* when *something reminded* you of a stressful experience from the past? | | | | | |
| 5. | Having *physical reactions* (e.g., heart pounding, trouble breathing, or sweating) when *something reminded* you of a stressful experience from the past? | | | | | |
| 6. | Avoid *thinking about* or *talking about* a stressful experience from the past or avoid *having feelings* related to it? | | | | | |
| 7. | Avoid *activities* or *situations* because they *remind you* of a stressful experience from the past? | | | | | |
| 8. | Trouble *remembering important parts* of a stressful experience from the past? | | | | | |
| 9. | Loss of *interest in things that you used to enjoy*? | | | | | |
| 10. | Feeling *distant* or *cut* off from other people? | | | | | |
| 11. | Feeling *emotionally numb* or being unable to have loving feelings for those close to you? | | | | | |
| 12. | Feeling as if your *future* will somehow be *cut short*? | | | | | |
| 13. | Trouble *falling* or *staying asleep*? | | | | | |
| 14. | Feeling *irritable* or having *angry outbursts*? | | | | | |
| 15. | Having *difficulty concentrating*? | | | | | |
| 16. | Being *"super alert"* or watchful on guard? | | | | | |
| 17. | Feeling *jumpy* or easily startled? | | | | | |

**PCL-M for DSM-IV (11/1/94)** Weathers, Litz, Huska, & Keane National Center for PTSD - Behavioral Science Division

Appendix B4

Traumatic Experiences Questionnaire

TRAUMATIC EXPERIENCE

ID: Mega_____ Date: _____

Below is a list of very traumatic or upsetting events that sometimes happen to people. Please indicate if any of these events have happened to you:

| | | |
|---|---|---|
| 1. Have you ever had direct combat experience in a war? | Yes ☐ | No ☐ |
| 2. Have you ever been involved in a life-threatening accident? | Yes ☐ | No ☐ |
| 3. Have you ever been involved in a fire, flood or other natural disaster? | Yes ☐ | No ☐ |
| 4. Have you ever witnessed someone being badly injured or killed? | Yes ☐ | No ☐ |
| 5. Have you ever been seriously attacked, assaulted or molested? | Yes ☐ | No ☐ |
| 6. Have you ever been threatened with a weapon, held captive, or kidnapped? | Yes ☐ | No ☐ |
| 7. Have you ever been tortured or the victim of terrorists? | Yes ☐ | No ☐ |
| 8. Have you ever experienced an extremely stressful or upsetting event? | Yes ☐ | No ☐ |
| 9. Have you ever suffered a great shock because one of the events on the list happened to someone close to you? | Yes ☐ | No ☐ |

If you are happy to be contacted for potential participation in a research study related to this questionnaire, please write your contact details below:

Name:_____

Email: _____

Mobile: _____

# Appendix B5

## Emotional Memory Diary

**EMOTIONAL MEMORY DIARY**

ID: Mega_____ Date: _____

1. You viewed a number of photographs two days ago when undergoing our study. How many intrusive memories (memories that have occurred spontaneously, not memories you have deliberately thought about) have you had in the past two days?

_____

2. Describe each intrusive memory in detail.

_____

_____

_____

_____

_____

3. Give a rating for how vivid your intrusive memories were

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | A little bit | Moderate | Quite a bit | Extremely |

4. Give a rating for how distressing your intrusive memories were

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | A little bit | Moderate | Quite a bit | Extremely |

Think about the pictures you were shown when you came to the experiment a few days ago. As you know, some of those pictures were pretty emotive and others were pretty neutral. Can you tell me which ***negative*** pictures you remember the best?

1. _____
2. _____
3. _____

I am interested in whether any of those ***negative*** pictures have popped into your mind at any time after the experiment. Thinking about any of those pictures, please read each item below and indicate how true each statement is for you.

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | A little bit | Moderate | Quite a bit | Extremely |

1. Any reminder brought back feelings of it. ____
2. I had trouble staying asleep. ____
3. Other things kept making me think about it. ____
4. I thought about it when I didn't mean to. ____
5. Pictures about it popped into my mind. ____
6. It was difficult to get these images out of my mind. ____

Think about the pictures you were shown when you came to the experiment a few days ago. As you know, some of those pictures were pretty emotive and others were pretty neutral. Can you tell me which ***positive*** pictures you remember the best?

1. _____
2. _____
3. _____

I am interested in whether any of those ***positive*** pictures have popped into your mind at any time after the experiment. Thinking about any of those pictures, please read each item below and indicate how true each statement is for you.

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | A little bit | Moderate | Quite a bit | Extremely |

1. Any reminder brought back feelings of it. ____
2. I had trouble staying asleep. ____
3. Other things kept making me think about it. ____
4. I thought about it when I didn't mean to. ____
5. Pictures about it popped into my mind. ____
6. It was difficult to get these images out of my mind. ____

Think about the pictures you were shown when you came to the experiment a few days ago. As you know, some of those pictures were pretty emotive and others were pretty neutral. Can you tell me which ***neutral*** pictures you remember the best?

1. _____
2. _____
3. _____

I am interested in whether any of those ***neutral*** pictures have popped into your mind at any time after the experiment. Thinking about any of those pictures, please read each item below and indicate how true each statement is for you.

| 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Not at all | A little bit | Moderate | Quite a bit | Extremely |

1. Any reminder brought back feelings of it. ____
2. I had trouble staying asleep. ____
3. Other things kept making me think about it. ____
4. I thought about it when I didn't mean to. ____
5. Pictures about it popped into my mind. ____
6. It was difficult to get these images out of my mind. ____

Appendix B6

Medical Questionnaire

## Medical and History Questionnaire

ID: Mega_____ Date: _____

**Medical History**

Are you currently suffering from anxiety or depression? _____

Have you ever been diagnosed with a psychiatric disorder? _____

Are you currently receiving counselling or psychological problems? _____

Do you have heart condition or any other serious physical condition?

_____

Are you currently taking any prescription medication? If so, what medication?

_____

Have in the past taken any medication for psychological condition(s)? if so, what medication?

_____

Is there any possibility that you could be pregnant?

_____

Have you ever had or are you now suffering from any of the following (please circle):

| | | |
|---|---|---|
| Fits or convulsions | Yes | No |
| Epilepsy | Yes | No |
| Giddiness | Yes | No |
| Concussion | Yes | No |
| Severe head injury | Yes | No |
| Loss of consciousness | Yes | No |

On average, how many cups of caffeinated drinks (coffee, coke or energy drinks) would you drink per day?

- ☐ None
- ☐ 1-2
- ☐ 3-4
- ☐ Over 5 cups

**Smoking History**

How often do you smoke cigarettes / tobacco / cigars / pipe? (please circle)

- ☐ Never
- ☐ Less than 5 per week
- ☐ Less than 5 per day
- ☐ 5 to 9 per day
- ☐ 10 to 19 per day
- ☐ 20 to 39 per day
- ☐ Over 40 per day

| | | |
|---|---|---|
| Do you or have you in the past used marijuana? (please circle) | Yes | No |
| a) Have you used marijuana in the last two weeks? | Yes | No |
| b) Have you used any other form of illicit drug in the last 6 months? | Yes | No |

How often do you smoke marijuana?

- ☐ Never
- ☐ Less than 5 per week
- ☐ Less than 5 per day
- ☐ 5 to 9 per day
- ☐ 10 to 19 per day
- ☐ 20 to 39 per day
- ☐ Over 40 per day

**Vision**

Do you have any difficulties with vision? (Please specify)

_____

If yes, are these difficulties corrected (i.e. glasses / contacts)

_____

Appendix B7

Depression, Stress, Anxiety Scales

# DASS21

*Name:* *Date:*

Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

*The rating scale is as follows:*

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

| | | | | | |
|---|---|---|---|---|---|
| 1 | I found it hard to wind down | 0 | 1 | 2 | 3 |
| 2 | I was aware of dryness of my mouth | 0 | 1 | 2 | 3 |
| 3 | I couldn't seem to experience any positive feeling at all | 0 | 1 | 2 | 3 |
| 4 | I experienced breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion) | 0 | 1 | 2 | 3 |
| 5 | I found it difficult to work up the initiative to do things | 0 | 1 | 2 | 3 |
| 6 | I tended to over-react to situations | 0 | 1 | 2 | 3 |
| 7 | I experienced trembling (eg, in the hands) | 0 | 1 | 2 | 3 |
| 8 | I felt that I was using a lot of nervous energy | 0 | 1 | 2 | 3 |
| 9 | I was worried about situations in which I might panic and make a fool of myself | 0 | 1 | 2 | 3 |
| 10 | I felt that I had nothing to look forward to | 0 | 1 | 2 | 3 |
| 11 | I found myself getting agitated | 0 | 1 | 2 | 3 |
| 12 | I found it difficult to relax | 0 | 1 | 2 | 3 |
| 13 | I felt down-hearted and blue | 0 | 1 | 2 | 3 |
| 14 | I was intolerant of anything that kept me from getting on with what I was doing | 0 | 1 | 2 | 3 |
| 15 | I felt I was close to panic | 0 | 1 | 2 | 3 |
| 16 | I was unable to become enthusiastic about anything | 0 | 1 | 2 | 3 |
| 17 | I felt I wasn't worth much as a person | 0 | 1 | 2 | 3 |
| 18 | I felt that I was rather touchy | 0 | 1 | 2 | 3 |
| 19 | I was aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat) | 0 | 1 | 2 | 3 |
| 20 | I felt scared without any good reason | 0 | 1 | 2 | 3 |
| 21 | I felt that life was meaningless | 0 | 1 | 2 | 3 |

Appendix B8

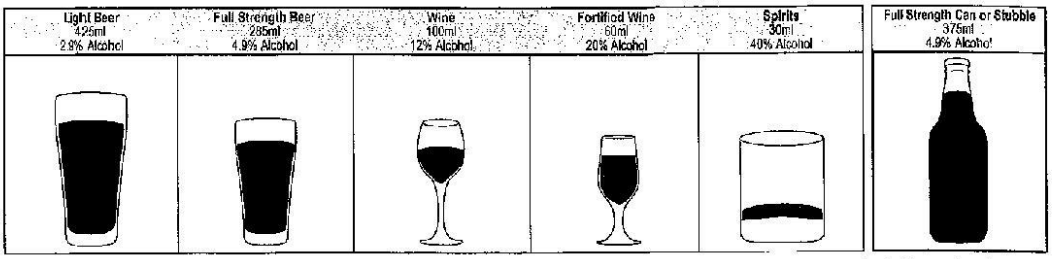
Alcohol Use Disorders Identification Test

Australian Government
Department of Veterans' Affairs

ID: Mega

# Alcohol Screen (AUDIT)

THE RIGHT MIX




*The guide above contains examples of* ***one standard drink.***

A full strength can or stubbie contains ***one and a half standard drinks.***

**Introduction**

Because alcohol use can affect health and interfere with certain medications and treatments, it is important that we ask you some questions about your use of alcohol. Your answers will remain confidential, so please be as accurate as possible. Try to answer the questions in terms of '**standard drinks**'. Please ask for clarification if required.

**AUDIT Questions** Please tick the response that best fits your drinking.

| | | | | | | Score | Sub totals |
|---|---|---|---|---|---|---|---|
| | *Never* | *Monthly or less* | *2 - 4 times a month* | *2 - 3 times a week* | *4 or more times a week* | | |
| 1. How often do you have a drink containing alcohol? | ☐ Go to Qs 9 & 10 | ☐ | ☐ | ☐ | ☐ | | |
| | *1 or 2* | *3 or 4* | *5 or 6* | *7 to 9* | *10 or more* | | |
| 2. How many standard drinks do you have on a typical day when you are drinking? | ☐ | ☐ | ☐ | ☐ | ☐ | | |
| | *Never* | *Less than monthly* | *Monthly* | *Weekly* | *Daily or almost daily* | | |
| 3. How often do you have six or more standard drinks on one occasion ? | ☐ | ☐ | ☐ | ☐ | ☐ | | |
| 4. How often during the last year have you found that you were not able to stop drinking once you had started? | ☐ | ☐ | ☐ | ☐ | ☐ | | |
| 5. How often during the last year have you failed to do what was normally expected of you because of drinking? | ☐ | ☐ | ☐ | ☐ | ☐ | | |
| 6. How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session? | ☐ | ☐ | ☐ | ☐ | ☐ | | |
| 7. How often during the last year have you had a feeling of guilt or remorse after drinking? | ☐ | ☐ | ☐ | ☐ | ☐ | | |
| 8. How often during the last year have you been unable to remember what happened the night before because you had been drinking? | ☐ | ☐ | ☐ | ☐ | ☐ | | |
| | *No* | | *Yes, but not in the last year* | | *Yes, during the last year* | | |
| 9. Have you or someone else been injured because of your drinking? | ☐ | | ☐ | | ☐ | | |
| 10. Has a relative, friend, doctor, or other health care worker been concerned about your drinking or suggested you cut down? | ☐ | | ☐ | | ☐ | | |
| | | | | | | TOTAL | |

| **Supplementary Questions** | *No* | *Probably Not* | *Unsure* | *Possibly* | *Definitely* |
|---|---|---|---|---|---|
| Do you think you presently have a problem with drinking? | ☐ | ☐ | ☐ | ☐ | ☐ |
| | *Very easy* | *Fairly easy* | *Neither difficult nor easy* | *Fairly difficult* | *Very difficult* |
| In the next 3 months, how difficult would you find it to cut down or stop drinking? | ☐ | ☐ | ☐ | ☐ | ☐ |

D97:8 - 8/03 - P1 of 2

# Appendix C

## Information Sheets and Consent Form

# Appendix C1

## Participant Information Sheet for PTSD participants

UTAS

*Participant Information Sheet*

**The effect of sleep quality and cognitive factors on fear extinction in PTSD**

**Invitation**
You are invited to participate in a research study examining the influence of sleep and cognitive factors on fear extinction in Posttraumatic Stress Disorder (PTSD). This study will be carried out in the Cognitive Neuroscience Laboratory at the School of Psychology, University of Tasmania (Hobart campus). The study is being conducted by the following people:

- Professor Kim Felmingham, supervisor and chief investigator, UTAS.
- Mr Daniel Zuj, PhD Candidate, UTAS.
- Mr Ken Chia, Masters student, UTAS.
- Ms Emma Nicholson, Masters student, UTAS
- Mr Luke Ney, Honours student, UTAS.

***What is the purpose of this study?***
The purpose of this study is to investigate the effect of sleep quality and a number of cognitive variables on fear extinction in PTSD. Previous research has indicated that difficulty in extinguishing fear is an important influence on the severity of PTSD symptoms. Recent research has also revealed that quality of sleep and cognitive variables (styles of thinking) can predict the severity of symptoms in PTSD. Therefore, the present study also aims to determine the degree that sleep difficulties (and additional cognitive variables) effect performance on a fear extinction task in PTSD.

***Why have I been invited to participate?***
You have been invited to participate in this study as you are currently receiving treatment from a psychologist for Posttraumatic Stress Disorder (PTSD). We are looking for volunteers who are not currently taking any medication and are aged between 18 and 55. You will be reimbursed $50 for your travel expenses and time (approximately two hours).

***What will I be asked to do?***
We will initially consult with you and your treating psychologist, to ensure your eligibility for participating in the study. If eligible, you will be asked to engage in two testing sessions at the Cognitive Neuroscience Laboratory in the School of Psychology, UTAS; an initial session where you will complete some questionnaires and view some emotional images from a standard picture series (some of these images will be negative and involve images of injury or violence, and may be mildly distressing). You will also complete some standard tests of verbal memory and verbal function and be asked to complete a behavioural task examining how your body arousal (sweat gland activity) reacts to a mild electrical stimulus that will be administered to your fingertips. You will first be asked to select a level of mild electrical stimulus that feels uncomfortable but not painful to you. This will be done by attaching a finger stimulator to your index finger and delivering the lowest level of electrical stimulus, the level of which will then be increased in small increments until you report that it feels uncomfortable but not painful. You will then be asked to complete the behavioural task. In this task, you will sit in front of a computer screen and small recording disks will be attached to your fingertips to measure your body arousal (via skin conductance). You will be asked to watch a computer screen, on which you will see different coloured circles (red or blue) appear. Following the presentation of some of these coloured circles, you will receive an

electrical stimulus, which will be set at the level you have previously chosen. You will also be asked to provide ratings on how much you are expecting to receive the electrical stimulus in the task. This behavioural task will last approximately 15 minutes. The first session will take approximately 90 minutes.

You will be asked to return for a second testing session two days later, that will take approximately 30 minutes where you will complete further questionnaires and a verbal memory task.

***Are there any possible benefits from participation in this study?***
If you decide to participate in this research, you will be reimbursed $50 for participating, gain experience in research procedures and also some knowledge of underlying mechanisms Furthermore, you will be involved in research that may help better understand the mechanisms and processes involved in the extinction of fear and PTSD, and this may also lead to more efficient and effective exposure treatments for anxiety disorders.

***Are there any possible risks from participation in this study?***
Prior to participation in this study, you will be asked to sign a consent form, which will evidence your agreement to participate. You may feel a small amount of arousal or discomfort from viewing the negative images or from the mild electrical stimulus. However, we expect this arousal or discomfort to be minimal, as these are standard images and are not graphic (similar to what would be seen on television crime shows) and the electrical stimulus level that is administered will have been selected by you to be uncomfortable but not painful. The technology used to administer this electrical stimulus is very safe and has been used in many previous studies with no adverse effects reported. There will be a researcher with you at all times, and you can discontinue the study at any time without penalty and it will not affect your relationship with the University of Tasmania or the School of Psychology or your current treatment.

***What if I change my mind during or after the study?***
Participation in this research is entirely voluntary. You may choose to withdraw from the study at any time without prejudice. Deciding to withdraw from this research at any time will not affect your treatment or your potential or future involvement with the School of Psychology, University of Tasmania, in any way. You can also choose at this time to withdraw any data previously collected. Participants will be given copies of this information sheet and the statement of informed consent.

***What will happen to the information when this study is over?***
Your individual data will be treated confidentially and your name will be replaced by an ID number on all data. Data will be kept in a locked filing cabinet or on password secured computers at the School of Psychology at the University of Tasmania for a period of at least five years.

***How will the results of the study be published?***
Following completion of the research, the data obtained from this study will be published. However, no participant will be personally identifiable in these publications, as only group data will be published. A summary of the results of these experiments will be available on the

UTAS

*Participant Information Sheet*

University of Tasmania School of Psychology web page at www.utas.edu.au/psychology or will be available by contacting the researchers.

***What if I have questions about this study?***
The researchers will be available after the testing session to answer any questions you may have. If you have any questions, or would like any additional information regarding this research, please contact Luke Ney at lney@utas.edu.au, or Professor Kim Felmingham at Kim.Felmingham@utas.edu.au.

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479, or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number [H0013304].

**Thank you for taking the time to consider this study.**
**If you wish to take part, please sign the attached consent form.**
**This information sheet is for you to keep.**

# Appendix C2

## Information Sheet for Controls

UTAS

*Participant Information Sheet*

**The effect of sleep quality and cognitive factors on fear extinction in PTSD**

**Invitation**
You are invited to participate in a research study examining the influence of sleep and cognitive factors on fear extinction in Posttraumatic Stress Disorder (PTSD). This study will be carried out in the Cognitive Neuroscience Laboratory at the School of Psychology, University of Tasmania (Hobart campus). The study is being conducted by the following people:

- Professor Kim Felmingham, supervisor and chief investigator, UTAS.
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- Ms Emma Nicholson, Masters student, UTAS
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***What is the purpose of this study?***
The purpose of this study is to investigate the effect of sleep quality and a number of cognitive variables on fear extinction in PTSD. Previous research has indicated that difficulty in extinguishing fear is an important influence on the severity of PTSD symptoms. Recent research has also revealed that quality of sleep and cognitive variables (styles of thinking) can predict the severity of symptoms in PTSD. Therefore, the present study also aims to determine the degree that sleep difficulties (and additional cognitive variables) effect performance on a fear extinction task in PTSD.

***Why have I been invited to participate?***
You have been invited to participate in this study as you are currently enrolled in psychology first-year undergraduate studies, or other studies at the University of Tasmania. We are looking for volunteers who are not currently taking any medication and are aged between 18 and 55. You will be provided with two hours course-credit for your participation, or reimbursed with $30.

***What will I be asked to do?***
We will initially consult with you and your treating psychologist, to ensure your eligibility for participating in the study. If eligible, you will be asked to engage in two testing sessions at the Cognitive Neuroscience Laboratory in the School of Psychology, UTAS; an initial session where you will complete some questionnaires and view some emotional images from a standard picture series (some of these images will be negative and involve images of injury or violence, and may be mildly distressing). You will also complete some standard tests of verbal memory and verbal function and be asked to complete a behavioural task examining how your body arousal (sweat gland activity) reacts to a mild electrical stimulus that will be administered to your fingertips. You will first be asked to select a level of mild electrical stimulus that feels uncomfortable but not painful to you. This will be done by attaching a finger stimulator to your index finger and delivering the lowest level of electrical stimulus, the level of which will then be increased in small increments until you report that it feels uncomfortable but not painful. You will then be asked to complete the behavioural task. In this task, you will sit in front of a computer screen and small recording disks will be attached to your fingertips to measure your body arousal (via skin conductance). You will be asked to watch a computer screen, on which you will see different coloured circles (red or blue)

appear. Following the presentation of some of these coloured circles, you will receive an electrical stimulus, which will be set at the level you have previously chosen. You will also be asked to provide ratings on how much you are expecting to receive the electrical stimulus in the task. This behavioural task will last approximately 15 minutes. The first session will take approximately 90 minutes.

You will be asked to return for a second testing session two days later, that will take approximately 30 minutes where you will complete further questionnaires and a verbal memory task.

***Are there any possible benefits from participation in this study?***
If you decide to participate in this research, you will be provided with two hours course credit for research participation, gain experience in research procedures and also some knowledge of underlying mechanisms Furthermore, you will be involved in research that may help better understand the mechanisms and processes involved in the extinction of fear and PTSD, and this may also lead to more efficient and effective exposure treatments for anxiety disorders.

***Are there any possible risks from participation in this study?***
Prior to participation in this study, you will be asked to sign a consent form, which will evidence your agreement to participate. You may feel a small amount of arousal or discomfort from viewing the negative images or from the mild electrical stimulus. However, we expect this arousal or discomfort to be minimal, as these are standard images and are not graphic (similar to what would be seen on television crime shows) and the electrical stimulus level that is administered will have been selected by you to be uncomfortable but not painful. The technology used to administer this electrical stimulus is very safe and has been used in many previous studies with no adverse effects reported. There will be a researcher with you at all times, and you can discontinue the study at any time without penalty and it will not affect your relationship with the University of Tasmania or the School of Psychology or your current treatment.

***What if I change my mind during or after the study?***
Participation in this research is entirely voluntary. You may choose to withdraw from the study at any time without prejudice. Deciding to withdraw from this research at any time will not affect your treatment or your potential or future involvement with the School of Psychology, University of Tasmania, in any way. You can also choose at this time to withdraw any data previously collected. Participants will be given copies of this information sheet and the statement of informed consent.

***What will happen to the information when this study is over?***
Your individual data will be treated confidentially and your name will be replaced by an ID number on all data. Data will be kept in a locked filing cabinet or on password secured computers at the School of Psychology at the University of Tasmania for a period of at least five years.

***How will the results of the study be published?***
Following completion of the research, the data obtained from this study will be published. However, no participant will be personally identifiable in these publications, as only group data will be published. A summary of the results of these experiments will be available on the

UTAS

*Participant Information Sheet*

University of Tasmania School of Psychology web page at www.utas.edu.au/psychology or will be available by contacting the researchers.

***What if I have questions about this study?***
The researchers will be available after the testing session to answer any questions you may have. If you have any questions, or would like any additional information regarding this research, please contact Luke Ney at lney@utas.edu.au, or Professor Kim Felmingham at Kim.Felmingham@utas.edu.au.

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479, or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number [H0013304].

**Thank you for taking the time to consider this study.**
**If you wish to take part, please sign the attached consent form.**
**This information sheet is for you to keep.**

Appendix C3

Participant Consent Form

UTAS

*Participant Consent Form*

**The effect of sleep quality and cognitive factors on fear extinction in PTSD**

**Participant Consent Statement:**

1. I agree to take part in the study named above.
2. I have read and understood the Information Sheet for this study.
3. The nature and possible effects of the study have been explained to me.
4. Any questions that I have asked have been answered to my satisfaction.
5. I understand that the study requires me to attend the Cognitive Neuroscience laboratory at the School of Psychology twice – once to complete questionnaires and view emotional images, and once where my arousal responses will be recorded whilst I view different coloured circles and receive a mild electrical stimulus to my fingers. I understand that I can set the level of this mild electrical stimulus to feel uncomfortable but not painful prior to the task.
6. I understand that all research data will be treated as confidential. I agree that research data gathered for the study may be published provided that I cannot be identified as a participant.
7. I understand that my participation is voluntary and that I may withdraw from participation and/or withdraw my data at any time without prejudice to my academic standing.

Participant's name: _____

Participant's signature: _____ Date: _____

**Investigator Statement**

I have explained this research and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

Investigator's name: _____

Investigator's signature: _____ Date: _____

# Appendix D

## Additional Results

Table D1

*Correlation Matrix of Original Variable Set*

| | | Group | PCL | DASS-Dep | DASS-anxiety | DASS-stress | PSQI-total | Hours Sleep – Session 2 | REM disturbance – Session 2 | AUDIT | Smoker | Meds | Negative Intrusive Memories |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group | *r* | 1 | | | | | | | | | | | |
| | Sig | | | | | | | | | | | | |
| PCL | *r* | .78** | 1 | | | | | | | | | | |
| | Sig | .000 | | | | | | | | | | | |
| DASS-Dep | *r* | .52** | .73** | 1 | | | | | | | | | |
| | Sig | .000 | .000 | | | | | | | | | | |
| DASS-anxiety | *r* | .59** | .75** | .73** | 1 | | | | | | | | |
| | Sig | .000 | .000 | .000 | | | | | | | | | |
| DASS-stress | *r* | .61** | .74** | .69** | .78** | 1 | | | | | | | |
| | Sig | .000 | .000 | .000 | .000 | | | | | | | | |
| PSQI- total | *r* | .53** | .56** | .45** | .39** | .46** | 1 | | | | | | |
| | Sig | .000 | .000 | .000 | .000 | .000 | | | | | | | |
| Hours sleep – Session 2 | *r* | -.23* | -.39** | -.31** | -.17 | -.27* | -.41** | 1 | | | | | |
| | Sig | .013 | .000 | .001 | .059 | .003 | .000 | | | | | | |
| REM disturbance – Session 2 | *r* | .40** | .49** | .31** | .34** | .32** | .39** | -.21* | 1 | | | | |
| | Sig | .000 | .000 | .001 | .000 | .000 | .000 | .025 | | | | | |
| AUDIT | *r* | .26** | .23* | .15 | .14 | .08 | .32** | -.07 | .11 | 1 | | | |
| | Sig | .004 | .013 | .118 | .133 | .376 | .000 | .442 | .219 | | | | |
| Smoker | *r* | -.17 | -.20 | -.06 | -.13 | -.17 | -.10 | -.01 | -.13 | -.28** | 1 | | |
| | Sig | .059 | .028 | .503 | .161 | .072 | .280 | .918 | .155 | .002 | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Meds | *r* | -.28** | -.31** | -.30** | -.20* | -.19* | -.20* | .15 | -.11 | -.03 | .02 | 1 |
| | Sig | .002 | .001 | .001 | .031 | .044 | .024 | .108 | .249 | .743 | .810 | |
| Negative | *r* | .41** | .37** | .14 | .22* | .27** | .37** | -.24** | .38** | .08 | -.07 | -.20* |
| Intrusive | Sig | .000 | .000 | .137 | .018 | .003 | .000 | .010 | .000 | .369 | .452 | .028 |
| Memories | | | | | | | | | | | | |

*Note:* *significant at $p < .05$. **significant at $p < .01$. *r* = Pearson's correlation co-efficient

Table D2

*Pairwise Comparisons using Sidak Post-Hoc Tests With Standard Errors, Significance Levels and 95% Confidence Intervals for Demographic and Clinical Data*

| | | | | 95% Confidence Intervals | |
|---|---|---|---|---|---|
| Measure | Comparison | SE | *p* | Lower bound | Upper bound |
| Age | PTSD and TE | 2.39 | .042 | .16 | 11.74 |
| | PTSD and NTE | 2.44 | .001 | 2.88 | 14.71 |
| | TE and NTE | 2.29 | .519 | -2.70 | 8.38 |
| DASS | | | | | |
| - stress | PTSD and TE | .92 | <.001 | 3.42 | 7.85 |
| | PTSD and NTE | .93 | <.001 | 5.69 | 10.21 |
| | TE and NTE | .88 | .028 | .19 | 4.43 |
| PCL | PTSD and TE | 1.75 | <.001 | 18.85 | 27.33 |
| | PTSD and NTE | 1.79 | <.001 | 23.69 | 32.35 |
| | TE and NTE | 1.67 | .012 | .87 | 8.98 |
| TEQ | PTSD and TE | .34 | <.001 | .77 | 2.43 |
| | PTSD and NTE | .35 | <.001 | 3.13 | 4.82 |
| | TE and NTE | .33 | <.001 | 1.58 | 3.17 |

Table D3

*Mean Scores and Standard Deviations for Participant Ratings of Valence and Arousal for Neutral, Positive and Negative IAPS images (Lang, et al., 2008)*

| Group | Valence Rating | | | Arousal Rating | | |
|---|---|---|---|---|---|---|
| | Neutral | Positive | Negative | Neutral | Positive | Negative |
| NTE (*n*=40) | 3.25 (1.02) | 4.88 (1.24) | 1.25 (1.07) | 1.58 (0.94) | 4.33 (2.05) | 6.25 (2.14) |
| TE (*n*=44) | 3.41 (1.12) | 4.71 (0.97) | 1.72 (1.38) | 1.78 (1.11) | 3.66 (1.77) | 5.92 (1.74) |
| PTSD (*n*=34) | 3.33 (1.16) | 4.34 (1.12) | 1.96 (1.76) | 1.93 (1.31) | 3.59 (1.92) | 6.03 (2.31) |
| Total (*N*=118)^ | 3.34 (1.10) | 4.67 (1.11) | 1.63 (1.41) | 1.75 (1.11) | 3.86 (1.91) | 6.05 (2.01) |

Table D4

*Number of Neutral, Positive and Negative Intrusive Memories in NTE, TE and PTSD Groups*

| Group | Number of Intrusive Memories | | |
|---|---|---|---|
| | Neutral | Positive | Negative |
| NTE (*n*=40) | .03(.16) | .05(.22) | .10(.38) |
| TE (*n*=44) | .07(.45) | .14(.46) | .57(.82) |
| PTSD (*n*=34) | .03(.17) | .24(.55) | 1.03(1.14) |
| Total (*N*=118) | .04(.30) | .14(.43) | .54(.89) |

Table D5

*Summary of Sleep Data on the Pittsburgh Sleep Quality Index, Hours of Sleep and REM Disturbance with DASS-Stress as a Covariate*

| Measure | NTE (*n*=40) | TE (*n*=44) | PTSD (*n*=34) | Total (*N*=118) | *F* (DoF) | *p* | Effect size $\eta_p^2$ |
|---|---|---|---|---|---|---|---|
| PSQI | | | | | | | |
| -Total | 4.45 (2.38) | 5.77 (2.40) | 9.18 (4.06) | 6.31 (3.51) | 8.91(2,114) | <.001 | .13 |
| Hrs Sleep | | | | | | | |
| -Session 2 | 7.54 (1.34) | 7.78 (1.25) | 6.60 (1.93) | 7.36 (1.57) | 3.78(2,114) | .026 | .06 |
| REM disturbance^ | | | | | | | |
| -Session 2 | 3.33 (4.46) | 4.61 (5.07) | 10.66 (9.43) | 5.92 (7.12) | 5.94(2,114) | .004 | .09 |

*Note:* ^ *F* Statistic, Significance Level and Effect Size reflect transformed data.

Table D6

*Pairwise Comparisons of Sleep Data between NTE, TE and PTSD Groups using Sidak Post-Hoc Tests with DASS – Stress as a Covariate*

| Sleep Measure | Comparison | SE | *p* | 95% Confidence Intervals | |
|---|---|---|---|---|---|
| | | | | Lower bound | Upper bound |
| PSQI | PTSD and TE | .14 | .005 | .11 | .78 |
| | PTSD and NTE | .16 | <.001 | .28 | 1.05 |
| | TE and NTE | .13 | .237 | -.09 | .52 |
| HRS2 | PTSD and TE | .38 | .021 | -1.94 | -.12 |
| | PTSD and NTE | .43 | .302 | -1.74 | .36 |
| | TE and NTE | .34 | .690 | -.49 | 1.17 |
| REM2 | PTSD and TE | .37 | .013 | .18 | 1.96 |
| | PTSD and NTE | .42 | .004 | .37 | 2.41 |
| | TE and NTE | .33 | .718 | -.49 | 1.13 |

Table D7

*Summary Statistics for the Moderating Effect of PSQI Score, with DASS – Stress as a Covariate*

| | | | | | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|
| | *b* | SE | *t* | *p* | Lower bound | Upper bound |
| constant | .51 | .24 | 2.12 | .037 | .03 | .98 |
| PCL^ | .58 | .31 | 1.85 | .067 | -.04 | 1.19 |
| PSQI^ | .25 | .18 | 1.34 | .182 | -.12 | .61 |
| PCL^*PSQI^ | .19 | .23 | .84 | .405 | -.26 | .63 |
| DASS-Stress^ | .003 | .10 | .03 | .978 | -.19 | .20 |

*Note:* ^ coefficients, standard errors, *t*-statistics, significance levels and confidence intervals reflect analyses performed on transformed data. Overall model: $F(4,113) = 6.17$, $p < .001$, $R^2 = .18$

Table D8

*Summary Statistics for the Moderating Effect of Hours of Sleep before the Second Session, with DASS – Stress as a Covariate*

| | | | | | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|
| | *b* | se | t | p | Lower bound | Upper bound |
| constant | .43 | .19 | 2.23 | .028 | .05 | .81 |
| PCL^ | .60 | .25 | 2.45 | .016 | .11 | 1.09 |
| HRS2 | -.04 | .05 | -.79 | .423 | -.13 | .06 |
| PCL^*HRS2 | -.23 | .11 | -2.00 | .048 | -.454 | -.002 |
| DASS-Stress^ | .03 | .09 | .31 | .758 | -.15 | .20 |

*Note:* ^ coefficients, standard errors, *t*-statistics, significance levels and confidence intervals reflect analyses performed on transformed data. Overall model: $F(4,113) = 6.06$, $p < .001$, $R^2 = .19$

Table D9

*Summary Statistics for the Moderating Effect of REM Disturbance before the Second Session, with DASS – Stress as a Covariate*

| | | | | | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|
| | *b* | SE | *t* | *p* | Lower bound | Upper bound |
| constant | .47 | .26 | 1.80 | .074 | -.05 | .99 |
| PCL^ | .59 | .33 | 1.80 | .075 | -.06 | 1.25 |
| REM2^ | .10 | .06 | 1.50 | .137 | -.03 | .23 |
| PCL^*REM2^ | .17 | .13 | 1.34 | .183 | -.08 | .42 |
| DASS-Stress^ | .01 | .11 | .12 | .903 | -.20 | .23 |

*Note:* ^ coefficients, standard errors, *t*-statistics, significance levels and confidence intervals reflect analyses performed on transformed data. Overall model: $F(4,113) = 5.45$, $p = .001$, $R^2 = .20$

# Appendix E

## Effect of Medication

Table E1

*Summary of Sleep Data on the Pittsburgh Sleep Quality Index, Hours of Sleep and REM Disturbance with Medicated PTSD Participants Removed*

| Measure | NTE (*n*=40) | TE (*n*=44) | PTSD (*n*=29) | Total (*N*=113) | *F* (DoF) | *p* | Effect size $\eta_p^2$ |
|---|---|---|---|---|---|---|---|
| PSQI | | | | | | | |
| -Total | 4.45 (2.38) | 5.77 (2.40) | 9.24 (4.24) | 6.19 (3.50) | 24.71(2,110) | <.001 | .30 |
| Hrs Sleep | | | | | | | |
| -Session 2 | 7.54 (1.34) | 7.78 (1.25) | 6.66 (1.84) | 7.41 (1.51) | 5.52(2,110) | .005 | .09 |
| REM disturbance^ | | | | | | | |
| -Session 2 | 3.33 (4.46) | 4.61 (5.07) | 10.86 (9.71) | 5.76 (7.05) | 9.25(2,110) | .000 | .14 |

*Note:* ^*F* Statistic, Significance Level and Effect Size reflect transformed data.

Table E2

*Pairwise Comparisons of Sleep Data between NTE, TE and PTSD Groups using Sidak Post-Hoc Tests with Medicated PTSD Participants Removed*

| Sleep Measure | Comparison | SE | *p* | 95% Confidence Intervals | |
|---|---|---|---|---|---|
| | | | | Lower bound | Upper bound |
| PSQI | PTSD and TE | .14 | <.001 | .28 | .94 |
| | PTSD and NTE | .14 | <.001 | .59 | 1.27 |
| | TE and NTE | .16 | .036 | .02 | .62 |
| HRS2 | PTSD and TE | .35 | .005 | -1.98 | -.29 |
| | PTSD and NTE | .36 | .041 | -1.75 | -.03 |
| | TE and NTE | .32 | .835 | -.53 | 1.01 |
| REM2 | PTSD and TE | .35 | .005 | .29 | 1.99 |
| | PTSD and NTE | .36 | <.001 | .64 | 2.38 |
| | TE and NTE | .32 | .588 | -.41 | 1.15 |

Table E3

*Number of Neutral, Positive and Negative Intrusive Memories in NTE, TE and PTSD Groups with Medicated PTSD Participants Removed*

| Group | Number of Intrusive Memories | | |
|---|---|---|---|
| | Neutral | Positive | Negative |
| NTE (*n*=40) | .03(.16) | .05(.22) | .10(.38) |
| TE (*n*=44) | .07(.45) | .14(.46) | .57(.82) |
| PTSD (*n*=29) | .00(.00) | .28(.59) | .97(1.15) |
| Total (*N*=113) | .04(.30) | .14(.44) | .50(.87) |

**Summary of Intrusive Memory Data with Medicated PTSD Participants Removed.** When medicated PTSD participants were removed from the analyses, the main effect of image valence [$F(2,220) = 32.22$, $p < .001$, $\eta_p^2 = .28$] and group [$F(2,110) = 7.49$, $p = .001$, $\eta_p^2 = .12$] remained. There were still more negative than neutral ($p < .001$, 95% CI [.33, .69]) and than positive ($p < .001$, 95% CI [.22, .57]) intrusions across groups. There was a trending difference between the number of positive and neutral intrusive memories ($p = .053$, 95% CI [-.247, .001]) that was not observed when medicated PTSD participants were included. Further, there were more reported intrusive memories by PTSD than NTE participants ($p = .001$, 95% CI [.13, .58]), but not than TE participants ($p = .248$, 95% CI [-.07, .38]). TE participants reported more intrusions overall than NTE at a trend level ($p = .055$, 95% CI [-.003, .402]). Specifically, Sidak post-hoc analyses of the interaction effect revealed that, similar to when medicated PTSD cases were included, PTSD participants reported more negative intrusive memories than NTE participants (PTSD 95% CI [.67, 1.26], NTE 95% CI [-.15, .35]), but not TE participants (TE 95% CI [.33, .81]). TE continued to display a trend towards significantly more negative intrusions than NTE participants.

Table E4

*Summary Statistics for the Moderating Effect of PSQI Score, with Medicated PTSD Participants Removed*

| | | | | | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|
| | *b* | SE | *t* | *p* | Lower bound | Upper bound |
| constant | .47 | .09 | 5.08 | <.001 | .29 | .65 |
| PCL^ | .51 | .28 | 1.85 | .068 | -.04 | 1.05 |
| PSQI^ | .25 | .18 | 1.38 | .170 | -.11 | .60 |
| PCL^*PSQI^ | .24 | .22 | 1.08 | .282 | -.20 | .68 |

*Note:* ^ coefficients, standard errors, *t*-statistics, significance levels and confidence intervals reflect analyses performed on transformed data. Overall model: $F(3,109) = 6.88$, $p < .001$, $R^2 = .17$

Table E5

*Summary Statistics for the Moderating Effect of Hours of Sleep before the Second Session, with Medicated PTSD Participants Removed*

| | | | | | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|
| | *b* | se | t | p | Lower bound | Upper bound |
| constant | .47 | .08 | 5.66 | <.001 | .31 | .64 |
| PCL^ | .67 | .21 | 3.14 | .002 | .11 | 1.10 |
| HRS2 | -.02 | .05 | -.41 | .680 | -.13 | .08 |
| PCL^*HRS2 | -.18 | .12 | -1.42 | .158 | -.42 | .07 |

*Note:* ^ coefficients, standard errors, *t*-statistics, significance levels and confidence intervals reflect analyses performed on transformed data. Overall model: $F(3,109) = 5.96$, $p < .001$, $R^2 = .15$

Table E6

*Summary Statistics for the Moderating Effect of REM Disturbance before the Second Session, with Medicated PTSD Participants Removed*

| | | | | | 95% Confidence Intervals | |
|---|---|---|---|---|---|---|
| | *b* | SE | *t* | *p* | Lower bound | Upper bound |
| constant | .47 | .08 | 5.72 | <.001 | -.05 | .99 |
| PCL^ | .58 | .21 | 1.80 | .007 | -.06 | 1.25 |
| REM2^ | .09 | .07 | 1.50 | .169 | -.03 | .23 |
| PCL^*REM2^ | .16 | .13 | 1.34 | .220 | -.08 | .42 |

*Note:* ^ coefficients, standard errors, *t*-statistics, significance levels and confidence intervals reflect analyses performed on transformed data. Overall model: $F(3,109) = 5.74$, $p = .001$, $R^2 = .18$

# Appendix F

SPSS Output (CD attached)